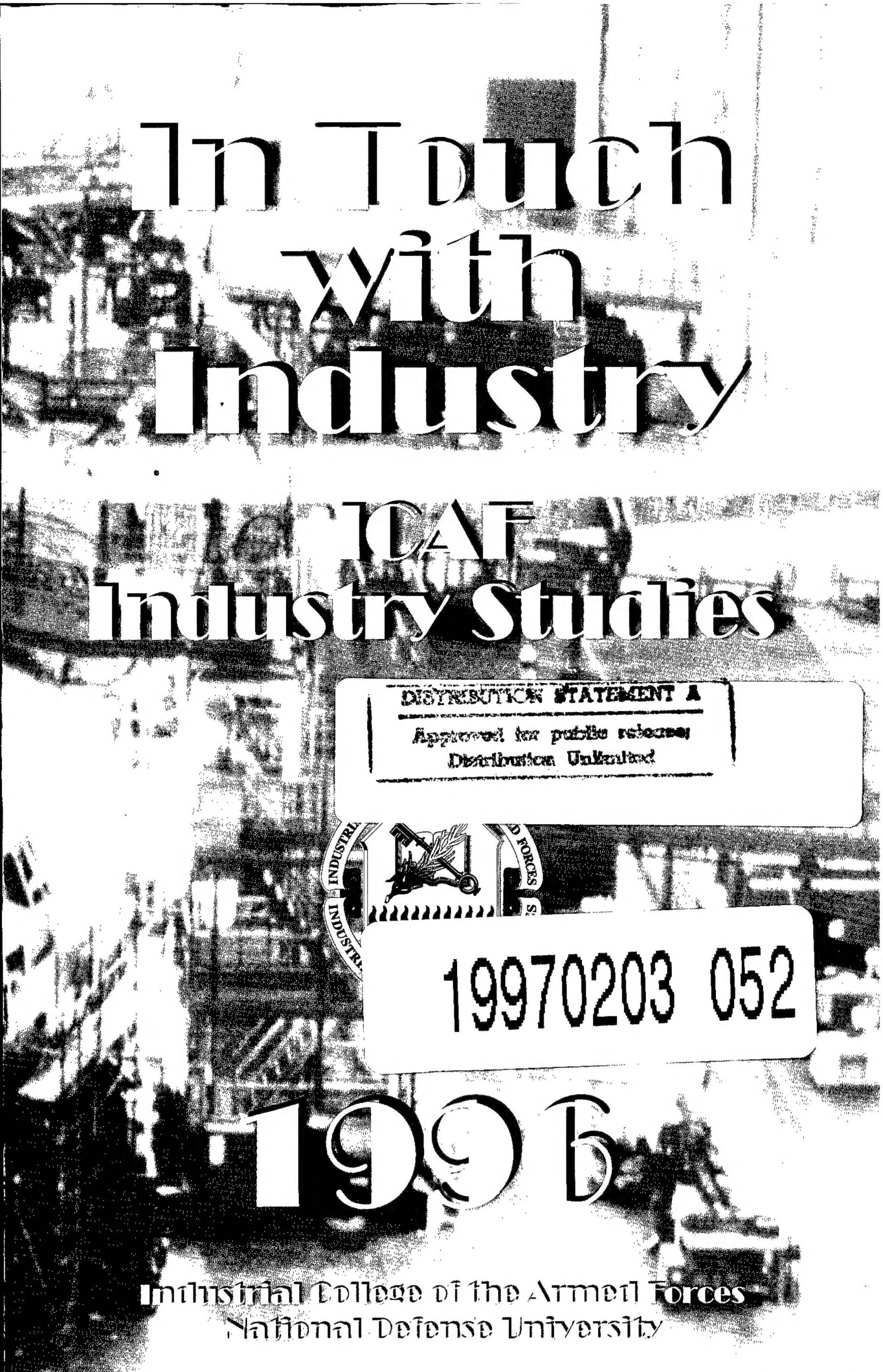

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IN TOUCH WITH INDUSTRY: ICAF INDUSTRY STUDIES, ACADEMIC YEAR 1996

GERALD ABBOTT, editor

1996

INDUSTRIAL COLLEGE OF THE ARMED FORCES
NATIONAL DEFENSE UNIVERSITY
WASHINGTON, DC 20319-5062

INDUSTRY STUDIES
ACADEMIC YEAR 1996

ADVANCED MANUFACTURING
AGRIBUSINESS
BIOTECHNOLOGY
EDUCATION
ENERGY
FINANCIAL SERVICES
INFORMATION
MUNITIONS
SPACE

ADVANCED MATERIALS
AIRCRAFT
CONSTRUCTION
ELECTRONICS
ENVIRONMENT
HEALTH CARE
LAND COMBAT SYSTEMS
SHIPBUILDING
TRANSPORTATION

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INDUSTRIAL COLLEGE OF THE ARMED FORCES

NATIONAL DEFENSE UNIVERSITY

WASHINGTON, DC 20319-5062

The 270 senior military and civilian students of the Industrial College of the Armed Forces form a cadre of individuals who will be making strategic decisions for the Nation. As part of the effort to prepare them for this critical role, they are assigned to one of 18 industry sector committees who share the same goal: to assess the ability of the U.S. and global industrial base to support our national security strategy.

Each committee's course of study is organized around a series of seminars with leading industry, government, and academic authorities. The committees also conduct field research and analysis of both domestic and foreign components of each industry. Visits are made to prime and subcontractor production facilities and headquarters, government activities, labor organizations, trade associations, logistics and distribution facilities, supporting financial institutions, and academic and research organizations.

One of the products of this five-month program is an executive summary of each committee's findings. The authors, while not experts, are generally well informed and bring to the study a collective wealth of technical, logistical, operational, and acquisition experience which significantly enhances their analysis. The summaries are published here for two purposes: to add to the general knowledge base concerning the overall status of the selected industrial sectors, and to offer specific policy recommendations for improving the industrial base's ability to support our national security requirements.

In closing, I would like to thank all those companies, associations, government activities, and academic institutions who so generously gave of their time. Their cooperation was essential in helping the Industrial College of the Armed Forces remain true to the charge made by Bernard Baruch at its founding in 1924, to "keep in touch with industry."

John S. Cowings
Major General, U.S. Army
Commandant

ADVANCED MANUFACTURING INDUSTRY STUDY REPORT 1996

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Caterpillar, York, PA
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Cincinnati Milacron, Cincinnati, OH
Mazak, Florence, KY
Honda of America, Marysville, OH
CTP Corporation, Indianapolis, IN
Air Force Materiel Command, Wright-Patterson Air Force Base, OH
Texas Instruments, Lewisville, TX

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Hong Kong Industrial Technology Center
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Guangdong Provincial Economic Commission, Guangzhou, China
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Nortel, Guangzhou, China
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Yamazaki Mazak, Nagoya, Japan
Okuma, Nagoya, Japan
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Nagoya, Japan
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ABSTRACT

This study of advanced manufacturing validates two facts: (1) manufacturing is vital to U.S. economic prosperity and national security, and (2) manufacturing will inevitably migrate out of mature industrial nations. The United States can reconcile these two facts only through a clear vision and a concerted effort by industry, academia, the Department of Defense, and the U.S. government. The report explores the nature of this vision and recommends actions to support it.

INTRODUCTION

Advanced Manufacturing Technology: The FY 94 Federal Program in Manufacturing Science, Engineering and Technology, highlights the importance of U.S. manufacturing: "Manufacturing is a cornerstone of the U.S. economy. The U.S. manufacturing sector directly employs 18 million people, or 17 percent of U.S. workers, and accounts for 22 percent of the U.S. gross national product--more than $1 trillion. Because jobs in manufacturing typically require more skills, these workers command a 20 to 30 percent premium in wages as compared with the average nonsupervisory U.S. worker in the private service sector. The manufacturing sector also employs approximately 75 percent of U.S. scientists and engineers and conducts 90 percent of the Nation's nondefense research and development." (Committee on Industry and Technology, 1993)

A large sector of U.S. manufacturing, the automobile industry, was caught off-guard in the late 1970s and early 1980s by the Japanese revolution in automobile production techniques and the demand for smaller, more fuel efficient automobiles. The Japanese automakers were able to take advantage of a slow-reacting U.S. auto industry by providing high-quality, low-cost cars to U.S. consumers. This phenomenon, termed *lean production* in *The Machine That Changed the World* (Womack, Jones, and Roos, 1991), began a revolution in Western industry that is still taking place today.

The history of the automobile industry also provides an excellent chronology of the evolution of manufacturing throughout the industrialized world. The first automobile was produced in 1894 by

Panhard et Levassor in Paris. The early manufacturing, called *craft production,* was typically done in small shops by skilled craftsmen. Henry Ford started using the process that came to be known as *mass production* with the Model T in 1908. What made mass production successful was the introduction of the moving assembly line by Ford in 1913.

Despite a number of innovations, the mass production system Ford developed continued almost undisturbed in the U.S. auto industry well into the 1980s. "This situation of stagnant mass production in both the United States and Europe might have continued indefinitely if a new motor industry had not emerged in Japan. The true significance of this industry was that it was not simply another replication of the by now venerable American approach to mass production. The Japanese were developing an entirely new way of making things, which we call lean production." (Womack, Jones, and Roos, 1991, 47).

When the major Japanese automakers began building production plants in the United States in the early 1980s, the U.S. auto industry finally took notice. In the mid-1980s, when Ford became the first U.S. auto manufacturer to discover lean production, what would become a rapid evolution of advanced manufacturing systems in the U.S. began.

The Evolution of Lean Production

The Japanese auto industry was forced to rebuild from scratch after the end of World War II. "Eiji Toyoda and his production genius, Taiichi Ohno, soon concluded that mass production could never work in Japan because: 1) the domestic market was tiny and demanded a wide range of vehicles, 2) the native Japanese work force was no longer willing to be treated as a variable cost, 3) the war-ravaged Japanese economy was starved for capital and for foreign exchange, and 4) the outside world was full of huge motor-vehicle producers who were anxious to establish operations in Japan. From this tentative beginning was born what came to be called the Toyota Production System and, ultimately, lean production." (Womack, Jones, and Roos, 1991, 49).

Lean production is the employment of some simple tenets involved in making things efficiently. Many of the following principles of lean

production were developed in Japan from the teachings of American W. Edwards Deming:

- Just-in-time (JIT), "small-lot" production.
- Minimal in-process inventories.
- Multiskilled workers.
- High levels of subcontracting.
- Selective use of automation.
- Continuous incremental process improvement.

The primary purpose of these principles is to improve the flow and continuity of production, use a pull versus a push inventory system, and eliminate waste. In fact, lean production is obsessed with quality and the elimination of waste; it depends on workers with the skills to solve problems, not pass them down the line. Lean production systems also allow a greater variety of products to be made and new models to go into production faster.

Lean is now evolving into *agile* and *hybrid* manufacturing. Agile manufacturing, the ability to thrive on constant change, adds additional flexibility to the lean system that forces it to change rapidly based on market conditions or customer requirements. In a truly agile system, a manufacturer can turn a profit on a production lot of one item! Hybrid manufacturing incorporates some of the innovations in advanced manufacturing techniques discussed below.

ADVANCED MANUFACTURING DEFINED

Advanced manufacturing is characterized by a flexible and responsive manufacturing system that can react rapidly to changing market conditions and customer requirements. Advanced manufacturing systems incorporate new technology and innovative business practices to rapidly deliver high-quality, customized products that customers want to buy. Advanced manufacturing processes require interrelated changes in product design, manufacturing operations, supplier management, information technology, and management systems. The team's research and visits to industry sites led to the identification of four major components of advanced manufacturing:

1. The effective and efficient use of machine tools and robotics in the manufacturing process.

2. The use of advanced engineering technologies (e.g., computer-aided design and manufacturing [CAD/CAM], rapid prototyping [RP], computer-integrated manufacturing [CIM], computer numeric-controlled [CNC] manufacturing equipment, flexible manufacturing systems [FMS], flexible machining centers) in the design and manufacture of products, as well as the effective use of both product and process research and development (R&D).

3. The effective use of information technology and systems to manage the design and production process, using techniques including cycle-time reduction, JIT production systems, material requirements planning (MRP), manufacturing resources planning (MRP II), manufacturing execution systems (MES), and quality systems such as International Standards Organization (ISO) 9000.

4. The effective management of organizational and human resources to provide a highly motivated, educated, trained, and empowered work force, including the effective use of concurrent engineering and integrated product teams (IPTs) in the development of new products and a team approach on the manufacturing floor.

Machine Tools and Robotics

Advanced manufacturing requires advanced machine tools and robotics. "It is not possible to have world-class manufacturing without world-class tools." (Dertouzos, Lester, and Solow, 1989, 20). Over the past 15 years the United States has lost much of the global machine-tool and robotics market to Japan, Germany and Italy even though demand for machine tools and robots is growing as the world economy recovers. The Robotics Industries Association reports that since 1991 robot orders have increased nearly 140 percent.

Advanced Engineering Technologies

Computer-aided design. CAD began as a simple, two-dimensional automated system to replace the manual production of engineering

drawings. Today's more sophisticated three-dimensional CAD systems allow the paperless design of parts and whole systems and give producers the ability to program and control the CNC machine tools producing the part.

Rapid prototyping. RP technologies cut the development time for new products by quickly producing prototypes for design verification and preliminary testing without the initial time and money required by traditional tool and die assemblies. The RP process feeds a 3-D CAD representation into an RP machine that produces the physical model. There are six basic RP technologies: stereolithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, solid ground curing, and ballistic particle manufacturing.

Flexible manufacturing systems. FMSs feature the use of high-variety production and design equipment such as robots, flexible machining centers, automatic insertion machines for electronic components, and CAD and engineering technology.

Computer-integrated manufacturing. CIM is an FMS plus automated and flexible control of the flow of materials and tools, the use of bar codes to identify all inventories and activities in the operation, and the automation of the knowledge work of production planning and control.

Information Technology and Systems

A number of techniques related to information technology and systems were developed to meet the goals of factory automation: higher quality, lower overhead, and faster response time.

Just-in-time. Lean production systems stress the importance of JIT throughout the production cycle. JIT systems, which can be as simple as a pencil-and-paper spreadsheet or as complex as a full MRP system, have the goal of reducing inventory requirements, increasing productivity, eliminating waste, and lowering costs.

Material requirements planning. The purpose of MRP is to determine when the workstation on the assembly line needs parts or when a

machining center needs raw materials. One element is a tool that makes the parts-purchasing and inventory control systems more effective.

Manufacturing resources planning. MRP II takes MRP to the next level by organizing the flow of manufacturing resources to meet delivery schedules while minimizing production costs. Functions that an MRP II system organizes include sales order management, inventory control, accounts receivable/payable, purchasing, and payroll.

Manufacturing execution systems. MES components include planning and scheduling, tracking, monitoring and control, quality management, and CIM interface. An MES assists production people in scheduling precisely, provides an electronic network for performance improvement, manages resources and dispatches production units, collects data automatically, delivers instructions and drawings to the workstation, records production details, manages alarms, analyzes performance, and continually interacts with the MRP II system. An MES brings automation to the shop floor to a much greater extent than MRP or MRP II does.

ISO 9000 quality systems. Management of quality, which used to be a lofty goal and an added cost of production, is now an absolute given for any company that hopes to become an advanced manufacturer today. Improved quality not only provides better products for the consumer but also eliminates waste and lowers costs. International quality standards, such as the ISO 9000 series quality standards, serve to level the playing field for manufacturers and provide a uniform set of criteria for quality. Quality systems include the organizational structure, responsibilities, procedures, processes, and resources needed to implement quality management. ISO 9000, a three-tiered approach to quality management systems, consists of ISO 9001, the high-level quality system, incorporating design, development, production, installation, and service into a total quality system; ISO 9002, the midlevel quality system, appropriate for production and installation only when design and development are not players; and ISO 9003, the low-level quality system, applicable to products in the final inspection and testing phase.

Management

An empowered work force. People are the most important asset of the modern manufacturing enterprise. A competitive work force requires a competitive organization and management structure. The individual worker is an asset to be developed, not a cost to be controlled. A work force consisting of multifunctional workers, the problem solvers in any organization, is facilitated by a flat organizational structure with empowered workers. Because a happy worker is a productive worker, the organization must focus on job satisfaction, which by some accounts is now more important to the average worker than monetary compensation.

Concurrent engineering. To significantly reduce product development times, manufacturers need to reduce the time that each phase takes and overlap the phases as much as possible. Concurrent engineering frees the design and development team from the step-by-step process of product development.

Integrated product teams. In IPTs, many functions in business enterprise (e.g., product design, engineering, manufacturing, marketing) collaborate in their management practices over the life of a product--from idea to obsolescence--to ensure that it reflects customers' needs. An IPT is generally formed for the life of the product development cycle and includes representatives from all functions responsible for developing and manufacturing the product: design, manufacturing, purchasing, quality, and suppliers.

CURRENT CONDITIONS

During our research and field studies, we visited manufacturers in the automotive, aerospace, electronics, and machine-tool industries as well as suppliers to these industries throughout the United States and in Hong Kong, China, and Japan. Below we summarize our observations on the current condition of manufacturing in the machine-tool, robotics, automobile, and electronics industries and on R&D in those countries.

Machine-Tool Industry

Recent performance paints a pessimistic portrait of the global competitiveness of the U.S. machine-tool industry today. After reducing the trade deficit in machine tools from 1987 until 1992, the industry completed 1995 with a projected record-high trade deficit of $3.54 billion (Womack, Jones, and Roos, 1996, S-4). This growth in the trade deficit overshadows the fact that domestic machine-tool production is also growing, but not as fast as U.S. consumption of machine tools. Meanwhile, the machine-tool industries in Japan and Germany are emerging from a recession and are increasing production at a greater rate than the U.S. machine-tool industry is.

As the Massachusetts Institute of Technology's Commission on Industrial Productivity observed in 1989, "The U.S. machine-tool industry has historically been fragmented, with small, mostly family-owned firms clustered in regions where user industries are concentrated. Each firm tended to specialize in a narrow product line for a particular market." (Dertouzos, Lester, and Solow, 1989, 234). Although the industry continues to consolidate, its overall structure continues to be one of relatively few large companies and hundreds of small companies. Of the 639 machine-tool firms active in 1992, almost 75 percent have fewer than 50 employees (Association for Manufacturing Technology, 1995, D-9). The top four U.S. companies in sales account for approximately 40 percent of domestic production.

A large percentage of U.S. machine-tool production continues to be in the area of "specialty" machines, leaving a large market for "commodity" machines to foreign competition. The United States' two largest competitors, Japan and Germany, continue to dominate large segments of the industry. "German firms stress high precision and special capabilities, whereas the Japanese concentrate on offering fast delivery of reliable, standard machines at low prices." (Dertouzos, Lester, and Solow, 1989, 233).

Domestic production continues to grow at an impressive rate--30 percent in 1995, with production estimated at $4.91 billion. (Production peaked at $5.1 billion before the industry's collapse in the early 1980s; Womack, Jones, and Roos, 1996, S-3). However, domestic consumption in 1995

grew 34 percent, causing a decrease in U.S. exports and an increase in imports. The resurgence of the economies and of the machine-tool industries in Japan and Germany, which grew 36 percent and 43 percent, respectively, overshadowed U.S. growth in 1995 (Womack, Jones, and Roos, 1996, S-1). Based on 1994 sales, the 4 largest and 8 of the top 15 machine-tool companies in the world are Japanese whereas only 3 U.S. firms, Giddings & Lewis, Western Atlas, and Cincinnati Milacron, made the top 15 (Ashburn, 1995, 87). Although U.S. machine-tool exports measured in dollars remained level from 1994 to 1995, exports as a percentage of production fell to a six-year low of 26.9 percent. Imports, in contrast, held at about 50 percent of U.S. consumption but soared on a dollar basis to $3.5 billion, an increase of 23.5 percent over 1994 (Womack, Jones, and Roos, 1996, S-3).

U.S. companies. U.S. machine-tool companies are taking different approaches to expanding their markets. Ingersoll Milling Company is developing high-velocity milling machines, particularly for the aircraft industry, and is redefining the state of the art in five-axis machining with its Octahedral Hexapod machine. They lead the industry in the development of linear motors to replace ball screws on large machining centers. Ingersoll is using a number of advanced manufacturing techniques. One is a CIM system that links design, manufacturing, and process controls, allowing the company to produce single, specialized parts at a cost that approaches the unit cost of a long run of a single standard part.

Cincinnati Milacron is becoming "lean" through its Wolfpack project, which involves "making machines that people actually want rather than engineering and building machines that someone within the organization maintains people have a yen for . . . and design[ing] for manufacturability, which has had a number of effects, including a 40 to 60% reduction in the number of parts used to build a machine and a 40% reduction in the cost of manufacture." (Womack, Jones, and Roos, 1994, 31). Milacron is also moving into plastics; 1994 sales of plastics machinery exceeded those for metalworking machinery.

Japanese companies. A key distinguishing feature of the Japanese machine-tool producers we visited (Yamazaki Mazak facilities in Japan and the United States and Okuma facilities in Japan) is a higher level of

automation than U.S. firms employ. Mazak and Okuma use FMSs in a fully automated mode, allowing both firms to man one shift and manage fluctuating production needs by operating a second shift, a third shift, or both without human intervention.

Robotics Industry

The Robotic Industries Association (RIA) reports that 10,198 robots valued at $898 million were shipped in 1995, a jump of 34 percent in units and 30 percent in dollars over 1994's record-setting pace. Robot shipments have increased more than 128 percent since 1991, when the robotics industry began surging forward. In 1995, spot-welding robots accounted for 36 percent of the new orders, followed by material-handling robots at 27 percent and arc-welding robots at percent. Although the RIA estimates that some 65,000 robots are now at work in U.S. factories, this figure represents only a fraction of the potential U.S. market. An RIA official estimates that fewer than 10 percent of the companies who could benefit from using robots have installed even one robot. Japan, on the other hand, had installed two-thirds of the robots in use worldwide by the late 1980s and still holds a commanding lead over the United States in the number of robots used in manufacturing.

Auto Industry

One focus of our study was the Japanese revolution in automobile production beginning in the late 1970s. Although Ford Motor Company and other U.S. manufacturers have introduced some "lean" innovations, the results do not resemble lean production in Japan.

As we saw during our visit, Honda of America has successfully brought Japanese-style production to the United States. U.S. workers there effectively use modified Japanese-style work and management techniques. Realizing the importance of job satisfaction, Honda takes care of its workers, and the U.S. workers at Honda of America feel as empowered as their counterparts in Japan do. The flat Honda organization empowers workers to solve problems on the line. The multiskilled work force at Honda allows jobs on the assembly line to change every two hours.

The production system at Toyota's Motomachi Assembly Plant in Japan more than fulfilled our high expectations. JIT delivery from suppliers is in full practice; trucks constantly pull up to the receiving docks. The plant contained no more than a two-hour supply of most parts, and the assembly line was restocked like clockwork every 20 minutes.

Parts of the Motomachi plant are highly automated. For example, the entire body-welding shop, which fabricates 12,000 bodies for Toyota and Lexus automobiles per month, ran with only 300 employees on two shifts. Four hundred thirty robot spot welders employed throughout the facility perform more than 96 percent of all spot welds (4,300). Production at the Motomachi plant is the best in the world, as evidenced by the fact that the 1996 J. D. Power and Associates *Annual Report on Auto Quality* rated the Lexus SC 300 and SC 400 coupes, built at Motomachi, at the top of the premium luxury section with the fewest problems reported by new owners. (*The Japan Times*, May 10, 1996)

Toyota realizes the value of its work force and has thus far lived up to its lifetime employment philosophy. A sign at the entrance to the Motomachi plant sums up Toyota's commitment to its work force:

- Increase worker motivation.
- Design processes that anyone can perform.
- Employ automation that people want to work with.
- Make a comfortable work environment.

Electronics Industry

At Texas Instruments, we saw the stereolithography rapid prototyping process, which converts a 3-D image into slices as thin as .0025 inch on a machine that can be operated without supervision. A low-power ultraviolet laser traces across the surface of a vat of photocurable liquid polymer, turning it into a hardened resin wherever the laser contacts the polymer. The hardened layer is then lowered incrementally to allow the next layer to form. Completed parts, which can be as large as 20 inches by 20 inches by 24 inches, have high resolution and good surface finishes. Texas Instruments uses stereolithography to produce models of a diverse range of products from castings to electronic components. The quality of

the models produced is so good that they can be used to make the molds for the castings.

Texas Instruments developed RP technology to reduce product development time and cost and to get products to market more quickly. The company estimates that it has saved $4.5 million over the past four years by using stereolithography prototyping.

The Nippondenso printed circuit board (PCB) production plant in Japan was the most automated of any facility we visited. The production line could handle up to seven different sizes of PCBs with only two or three human operators.

PCB manufacturing in Hong Kong was almost as automated and efficient as in Japan. In China, however, developing a work force in PCB manufacturing is a challenge, even though the United States, Japan, and Hong Kong are establishing advanced facilities there. Most firms responded to the work force problem by bringing in managers and engineers from the home country or from Hong Kong.

Research and Development

The Japanese commitment to R&D is legendary. "Despite the worst recessionary period in its post-war history, the Japanese economy continues to support massive expenditures for R&D. Outlays for 1994 are down from previous years, but still 40% above the amount spent 10 years earlier. Surprisingly, R&D expenditures in Japan have weathered the recession quite well, continuing to increase even after the growth of Japan's real GDP plunged from a high of 7.5% in 1990 to 1% in 1994. In fact, although economic growth has been almost nonexistent for the past three years, R&D expenditures have decreased by only 1%. In the U.S., on the other hand, R&D expenditures as a percentage of the GDP have declined by an average of 0.93% annually, even though the economy has been expanding for the past three years." (Henry, 1996, 2-3).

NGK Insulators illustrates the Japanese commitment to R&D. The company, which is recovering from a recession that has reduced its sales over the past five years, continues to pour 5-6% of revenues into R&D.

NGK's management sees this as the only way to maintain its competitiveness when the economy fully recovers.

CHALLENGES

Human Resources

A major challenge for the United States as it moves toward advanced manufacturing is human resources and corporate culture. U.S. industry traditionally has not taken a long-term view of growth, seeing U.S. workers as a variable cost that can be cut by downsizing, layoffs, and other methods. Companies tend to make capital expenditures based on a quick payback, sometimes within the next financial reporting period.

In contrast, Japanese companies continue to invest in technologies and in capital equipment that may not yield a payback for 10 or 20 years. A U.S. exception is Kellogg, the breakfast food manufacturer, which recently established a plant in China but does not expect it to be profitable for many years. The company has taken a long-term view of its venture in China not only because of the potential of the Chinese market but, as a Kellogg executive told us, for the long-term survival of the Kellogg company.

Since U.S. industry sees workers as expendable, training, particularly in how to work as a team, is lacking. "A company may decide to use teams, but only after it has cultivated the capabilities that will allow teams to be effective: credibility and trust between functional groups and a cadre of effective team leaders." (Hayes and Pisano, 1994, 86). Building successful teams violates the sanctity of two traditions of U.S. industry: the organizational hierarchy and the expendability of workers. The team concept is more natural to Japanese companies, which have a cultural heritage of concern for the group.

Productivity

Another challenge to U.S. industry is in the area of productivity and process improvements. "Many Japanese factories practicing lean manufacturing appeared to surpass their U.S. counterparts on several dimensions; they achieved lower cost, higher quality, faster product

introductions, and greater flexibility, all at the same time." (Hayes and Pisano, 1994, 80). U.S. companies are beginning to make progress in this area, as shown by the increased U.S. investment in advanced machine tools and robotics mentioned above. Investment in advanced CNC machine tools and in such areas as flexible machining centers, flexible design and manufacturing teams, factory simulation, and cycle-time reduction would improve productivity in U.S. factories.

Another area for improvement in productivity is manufacturers' relationships with suppliers. Suppliers play a much more central role today in product design and delivery. When companies use an electronic data interchange system, suppliers can have instant access to production data on orders, deliveries, defective items, etc. Today, instead of "arms-length" relationships with suppliers, manufacturers must maintain "arms-around" relationships. JIT inventory, involvement in the design process, and loyalty are all areas where manufacturers and suppliers must work together to improve productivity and process.

Investment in R&D

The United States continues to be the world leader in developing advanced manufacturing technologies. Decreasing expenditures on defense R&D without increasing those for commercial R&D will cause U.S. industry to lose the technological lead to industry in other countries.

The loss of U.S. industries to the emerging markets in Asia and Mexico is a sign not of the defeat of U.S. industry but of a natural progression toward locating more high-volume, low-complexity manufacturing in countries that are just mastering the concepts of mass production. The challenge for U.S. industry is to retain and advance its ability to design and develop complex, high-value-added manufacturing in the United States.

OUTLOOK

The long-term outlook for U.S. manufacturing is conditioned on much of what has already been discussed.

U.S. manufacturers can remain globally competitive only if they are willing to make the investments required. "Capabilities that provide enduring sources of competitive advantage are usually built over time through a series of investments in facilities, human capital, and knowledge." (Hayes and Pisano, 80). Two of the United States' biggest global competitors, Japan and Germany, are coming out of long recessions. As mentioned, Japanese companies continued to invest in research and product development even when sales were down. As they now begin an economic upswing, the high cost of continuing R&D will make Japanese companies even more competitive globally. Whether industry takes a long-term view of capital investment and investment in human resources, supported by the active influence of the government, will determine whether the United States remains competitive in the global marketplace or continues to lose out to the manufacturers of Japan, Germany, and the emerging global players.

High-Value Production

The future for manufacturing in the United States does not lie in returning to the status quo of the 1970s. "The key to future national wealth is not standardized mass production, but high value production--the creation of goods and services than command a premium market price because customers place high relative value on those products." (Reich, 1991, 81). The United States must continue to concentrate on complex, high-value-added manufacturing while taking advantage of opportunities in less developed countries for high-volume, low-complexity manufacturing. To maintain its technological lead, the United States must invest in areas like CAD/CAM, rapid and virtual prototyping, factory simulation, factory automation, and the design of the factories of the future. Developing the human resources required to accomplish these tasks, through education, training, worker involvement and empowerment, and the use of teams in the design, development, and manufacturing processes, is the key to future competitiveness.

Machine-Tool Industry

Advanced machine tools are critical to U.S. manufacturing. Although the U.S. machine-tool industry is proud of its 30 percent growth during 1995,

without increased productivity and increased plant capacity further growth will be slow. The world machine-tool market continues to grow at a rapid pace, but the U.S. industry continues to trail those of Japan and Germany in total sales. Continued R&D by major U.S. machine-tool builders can help maintain the U.S. position as the world leader in high-technology, specialized machine tools.

Support for National Security

Can U.S. manufacturing support national security resource requirements? The answer undoubtedly is yes, but the nature of that support will change. Off-shore production is now a fact of life for the United States and the rest of the industrialized world. The key for the advanced-manufacturing nations is to keep product and process expertise in the home country to maintain capabilities.

The future holds a number of challenges to meeting full surge and mobilization requirements. One of the most serious of those challenges concerns the implications of a JIT environment for surge and mobilization. A diminished but ever-changing threat means that the definition of mobilization formulated during the 1940s and envisioned during the Cold Car is probably obsolete. During the Cold War, a massive defense-related industrial base planned and executed surge and mobilization. Now that the defense-related industrial base is a smaller part of the national industrial base, flexible commercial manufacturers are the key to surge and mobilization. Because advanced manufacturers can adjust to changing requirements rapidly, future efforts to maintain surge and mobilization capabilities need to focus on second- and third-tier producers and suppliers who provide the parts and subassemblies to the end-item manufacturers.

An example of what one leading consumer goods producer, Levi Strauss, is doing to remain competitive illustrates what the future holds for mass production--in lots of one:

> One of the most dramatic benefits of the new technology may be the way it is changing the production of goods. Collecting customer data allows companies to deviate from the mass-production model, where a standard, assembly-line item is supposed to satisfy all consumers.

> With the new "mass customization," products can be efficiently made for a single person. At 19 Levi Strauss stores, for example, shoppers don't have to pick blue jeans off the shelf. Instead, customers can be measured for an exact fit and choose options, such as the color of the jeans. The data are then sent via modem to the Levi's factory in Tennessee, where the custom jeans are stitched. Approximately three weeks later, the perfect-fitting jeans are mailed to the consumer. The measurements are also kept on computer for future orders. Analysts believe that many goods will soon be delivered in a similar fashion because customized production cuts overhead. There is little waste, for instance, and inventory and transportation costs decline dramatically. (Cohen, 1996, 54)

GOVERNMENT GOALS AND ROLE

The large decrease in defense spending has caused the government's role in the U.S. manufacturing sector to shrink along with the defense industrial base. However, there is a continuing role for the government to play in shaping U.S. manufacturing for the 21st century.

Government-funded R&D since the end of World War II has provided the impetus for U.S. economic and manufacturing growth. With defense R&D spending on the decline, U.S. industry must now pick up much of the slack. In government-supported R&D programs, cooperative efforts with businesses, such as those used by SEMATECH and the Advanced Research Projects Agency, will ensure that the technologies developed match industrywide priorities.

Another role the government can play in improving the U.S. future in manufacturing is to support a U.S. export focus that will help maintain a positive balance of trade. Two means to achieve this are a more effective use of "technology attaches" in U.S. embassies abroad and support for U.S. Expo Centers in major markets abroad. These two steps will facilitate continued access to emerging technologies in the world and help market U.S. products and technologies in the global marketplace.

Tax, regulatory, trade, and program policies are another area in which the government can provide incentives to U.S. manufacturing. Favorable investment tax policies would encourage private sector capital investment

in maintaining R&D capabilities in the United States and would foster increased U.S. investment in the flexible manufacturing advances that are so critical to maintaining a viable advanced manufacturing capability.

Another way for the U.S. government to support manufacturing is to do no harm to U.S. industry by unnecessary government intervention. One example is trade sanctions in U.S. foreign policy and their impact on U.S. manufacturers.

A major segment of U.S. industry that has largely failed to take advantage of the "lean" revolution is the defense industrial base. The primary reason for this failure is the way the Department of Defense (DoD) buys major weapons systems. Some of the laws, rules, and regulations that government agencies must follow when expending public funds do not facilitate efficient production. The DoD has an important role to play in the U.S. manufacturing sector. As the defense industrial base continues to shrink, the DoD should reduce the number of government-owned and -operated manufacturing and repair facilities to only those fulfilling needs unique to defense that the commercial marketplace cannot supply. Examples include the production of submarines, tanks, combat vehicles, and certain fighter aircraft. Beyond these defense-unique requirements, the DoD should rely on an agile and flexible commercial manufacturing sector to meet defense needs.

The DoD should also continue to focus on basic research in defense laboratories and universities to ensure that the United States maintains the leading edge in advanced technologies for national security. In addition, funding to develop manufacturing flexibility in both the defense industrial base and the commercial manufacturing sector will help fulfill future needs for surge and mobilization capability.

Just as industry should be taking the long view, so should the DoD. Long-term relationships with valued suppliers are important to long-term national security. Government/private sector cooperation through multiyear budgets and contracts allows both parties to look beyond the next budget cycle. Long-term R&D in both product and flexible manufacturing processes will help the United States remain competitive in the global marketplace.

CONCLUSIONS

Paul Kennedy, in *Preparing for the Twenty-First Century,* offers the following recipe for improving U.S. competitiveness in the global marketplace:

> Increase national savings rates and slash budgetary deficits which drain funds from productive investment; enhance the levels of commercial R&D; avoid the diversion of too many resources to the military; escape (but how?) from a business culture that has become too dependent upon Wall Street's expectation of short-term profits; focus upon making well-designed, reliable products for the world's most demanding markets; vastly improve the levels of skill and training among the work force at large and provide opportunities for thorough retraining; and raise the educational standards, especially for those not going to college. (Kennedy, 1993, 337)

A commitment to advanced manufacturing requires the United States to do all that Kennedy suggests and more. The current U.S. technological advantage over global competitors will fall short in the future if the nation does not exploit that advantage for increased global competitiveness. The United States needs to develop a vision of manufacturing for the future. For industry to do what it has done for the past 100 years will only speed the inevitable shift of manufacturing from U.S. shores. Future U.S. national and economic security requires a commitment to keep a globally competitive advanced manufacturing capability in the United States.

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ADVANCED MATERIALS INDUSTRY STUDY REPORT 1996

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ABSTRACT

The advanced materials industry produces materials with superior performance characteristics that enable end products to be better than those made from conventional materials; it does not produce the end products. Although the federal government, especially the Department of Defense, sponsored much of the original research and development of advanced materials, that funding has recently been reduced significantly. Commercial users now dominate the AMATs market, and most segments of the industry in turn are dominated by a few producers. Recent industry trends include downsizing and an increase in foreign ownership. Despite these recent trends, access by U.S. manufacturers to AMATS both for economic growth and to meet national security needs is not threatened. However, this strategic arena needs to be closely monitored from a national security perspective.

INTRODUCTION

This report describes the advanced materials (AMATs) industry and market., current conditions and trends, and the ability of the industry to meet national security needs and to contribute to the economic well-being of the country.

What Is an Advanced Material?

AMATs are engineered materials. Their molecular structure has been "designed" to achieve specific performance characteristics in specific applications. They are used by industries such as aerospace, biotechnology, defense, electronics, and energy. AMATs include such products as aircraft skin, turbine blades, sporting goods, and computer chips. Their characteristics may include superior strength at high temperatures, high stiffness, high hardness, low thermal expansion, high conductivity, low thermal conductivity, superconductivity, or a high strength-to-density ratio.

AMATs can be classified according to (1) the way their atoms are held together, their internal structure, or both (e.g., metals, intermetallics, ceramics, polymers, composites, or glasses) and (2) their primary functional property (e.g., structural or mechanical, electronic, optical, or

magnetic). Our review focuses on only three of the materials studied: ceramics, composites, and metals, particularly specialty metals such as titanium.

Why Are Advanced Materials Important?

The improved performance achievable through the use of AMATs *contributes to economic growth and to superior commercial and military systems.* In some cases, they may make possible entirely new products and systems that would otherwise not exist. For example, the development of superalloys made gas turbine technology possible. Ceramics and intermetallic composites are under development to further improve performance. Three of the many other examples are glass fibers for communications, superconductors for sensitive magnetic measurements and possibly for power transmission, and polymer matrix composites for aircraft and perhaps for other transportation vehicles.

THE ADVANCED MATERIALS INDUSTRY DEFINED

The AMATs industry does not conform to the traditional definition of an industry because it does not produce finished products. Rather, the AMATs industry provides a *technology that enables products to perform better* than they would if conventional materials were used.

Most sectors of the AMATs industry are oligopic in nature. There are, for example, only a few makers of titanium or metal matrix composites, superalloys, high-end ceramics, and intermetallics.

A complication of the AMATs industry is *the high cost of capitalization and facilities*. The manufacturing techniques used to produce AMATs are exacting and have small tolerances. Also, because the industry must keep pace with the demand for better and better performance, high research and development (R&D) costs are associated with the constant evolution of material. All these high costs conspire against entry by small firms.

The manufacturers of AMATs take two forms: small specialty firms and divisions of large manufacturing enterprises. The small companies typically provide a variety of metals, resins, or polymers that have distinct characteristics of use to a specific buyer. The large manufacturers have

generally become involved in the AMATs industry as a natural outgrowth of existing business lines. They are more likely to use the AMATs they produce in an end product that they manufacture themselves. An example of the latter is DuPont, whose ceramic composite and thermoplastic businesses were a natural outgrowth of almost two centuries of work with chemicals.

Defense needs largely guided and financed the initial development of AMATs. As the Cold War ended in the early 1990s, however, defense spending in general began a steep decline. Almost simultaneously, commercial markets increased their use of AMATs. Unfortunately, as a result of reduced government investment, high capitalization costs, and short-term corporate focus, R&D is not proceeding as quickly as it did previously.

CURRENT CONDITIONS

The last five years have witnessed significant changes in the industry.

Manufacturers Are Downsizing

Many AMATs manufacturers have been forced to *downsize and consolidate* their businesses commensurate with Department of Defense (DoD) R&D budget reductions. In addition, the tremendous cost of capitalization and the relatively small markets for AMATs have caused some industrialists to abandon the business.

Foreign Suppliers Are Gaining Ground

In addition, many AMATs manufacturers have moved offshore. The production of AMATs by foreign sources is a phenomenon that the U.S. government must face in the future. The United States must deal with possible dependency not only on foreign sources but on transnational corporations.

Commercial Applications Dominate

Although the defense drawdown reduced the use of advanced composites and specialty metals, growth in the civilian use of a broad spectrum of

AMATs has sustained growth in the industry. Sporting goods and commercial space applications now dominate the market.

Overcapacity Is Common

Significant overcapacity and idle high-value machinery are common. Firms cut their work forces drastically three, four, or five years ago, but plant and equipment are not easily sold in time of significant downturn. These conditions are particularly evident in the titanium industry. Concurrent with defense procurement reductions, the entrance of the former Soviet Union's titanium production capacity further lowered market prices. U.S. firms are producing at only 30 percent of capacity and have not been profitable since 1990. Market growth in the commercial sector and adjustment to the former Soviet Union's high-volume but lower-quality production should cause a turnaround in 1996.

Recent Growth is Evident

Table 1. Shipments of Thermoset and Thermoplastic Resin Composites by Market, 1991-1994 (millions of pounds)

Composite	1991	1992	1993	1994
Aircraft/Aerospace/Military	39	32	25	2
Appliances/Business	135	143	148	16
Construction	420	483	530	59
Consumer Products	149	162	166	17
Corrosion-Resistant	355	332	352	37
Electrical/Electronic	231	260	275	29
Marine	275	304	319	36
Land Transportation	682	750	822	94
Miscellaneous (1)	74	83	89	10
Total	2,360	2,549	2,726	3,043

Source: SPI Composites Institute. ([1] Includes reinforcements and fillers.)

During the same period shipments of advanced carbon fibers increased a stunning 54 percent. By contrast, shipments of impregnated material (woven carbon fibers embedded in flexible resin, most often used for defense applications) declined from a high of 26 million pounds in 1991 to 20 million pounds in 1994.

Level of Information Technology Varies

The information technology used by the AMATs industry varies widely in its degree of sophistication. Typical of the industry is one large company's product divisions, which are organized and challenged to compete worldwide. They use state-of-the-art telecommunications to keep in touch, including a worldwide corporate e-mail system. Likewise, the product divisions are establishing a corporate technology transfer office to communicate with other companies, the government, and universities. Another company uses a sophisticated optical measuring system to check the final sizes of precision ceramic parts and an electronic drawing system to control the configuration of job orders on the factory floor.

The information technology used by much of the rest of the industry, however, does not approach this level of sophistication. One company showed us a state-of-the-art computer-assisted design and engineering system but admitted that some of the engineers still preferred to draw circuits by hand. While most companies we visited use personal computers in some automated processing, their information technology equipment is often not state of the art because capital is not available for the necessary upgrades.

Profitability Is Not Common

Large segments of the AMATs industry are not profitable because commercial markets cannot always bear the high cost of producing these exotic materials in the small quantities ordered. For example, according to the Titanium Institute, no titanium makers turned a profit in several years. Yet other segments of the AMATs industry, such as ceramics and high-end polymers, have done well and expect to do better in 1996.

Probably *the most profitable sector of the AMATs industry is sporting goods.* For example, makers of composite-shaft golf clubs are doing well with graphite-shaft and titanium-head golf equipment because sporting goods are produced from composites that have excellent properties, but they do not have the exacting specifications of the products invented for the aerospace industry and other demanding environments.

The industry as a whole is not expected to become profitable in the near future.

CHALLENGES

Twenty years ago, the greatest challenge facing AMATs manufacturers was technological development, particularly in support of the development of high-end products for government and military applications. Historically, the DoD played the decisive role in guiding, funding, and procuring AMATs products. Declining budgets and a significant reduction in military and government contracts have changed dramatically the long-standing status quo between U.S. industry and the government.

The most serious of the myriad challenges facing the AMATs industry are the following.

The Changing Role of Government

Historically, the U.S. government, particularly *the DoD, was the pioneer* in the AMATs area. Some of the results are the SR-71, flying since the 1960s, with large sections made of titanium alloys; the F-117 and the B-2, with skins made mostly of advanced composites; and the M-1 series tanks, with composite armor plating.

In contrast, since 1990 *government-sponsored research and production contracts have declined significantly, and much of the industry was unprepared.* Many AMATs manufacturers were economically and operationally structured to produce only to government requirements. As the government terminated contracts and deferred future plans, many manufacturers were forced to reduce their operations or to look for business opportunities outside the DoD. In addition, *the government did not offer specific financial support* as industry cut back. Revolutionary

changes in corporate business planning were required, resulting in a reorientation toward global, lower-end markets (e.g., sporting goods, automotive products).

More recently, however, the U.S. *government has sponsored R&D* via contracts and grants, although at a lower level than previously. These grants are aimed at both basic research and at efforts leading to commercial application of new materials and processes. Production contracts for programs involving AMATs remain sparse.

Substantial Fixed Investment

In the early 1980s, during the Reagan Administration's defense buildup, grants and contracts to push the edge of the technology envelope. This *the future of AMATs seemed endless,* particularly in advanced military applications. The government was aggressively supporting R&D through support led to the creation of radar-absorbing and -deflecting material, protective plating, and electronically conductive material. As a result, *many U.S. firms entered the AMATs business and invested* significantly in expensive equipment with long payback periods.

In 1990, the downturn in defense spending meant that many AMATs contracts were canceled. Saddled with huge investments, companies found that their *overhead costs immediately increased, making their market positions less competitive*. In serious cases, companies became unable to cover fixed or even variable costs. The U.S. corporate responses to these problems ranged from restructuring, to joint ventures, to outright sale of AMATs businesses, often to foreign corporations. In some cases, notably the titanium industry discussed above, substantial overcapacity continues to exist.

Global Competition

The technological and production *lead held in AMATs by U.S. companies in the 1980s has evaporated* as Japanese, British, and German companies have eclipsed those in the United States and the amount of U.S. government-funded R&D has declined. Concurrently, the stockholders of U.S. publicly held companies have pressured them to produce short-term positive results. These two interrelated problems have caused corporate

managers to reduce corporate-sponsored R&D, which jeopardizes the future of the U.S. AMATs industry.

In the meantime, *many foreign nations have made the growth of domestic AMATs industries and related suppliers an explicit goal* and a part of their national economic plans. Government assistance, monetary as well as regulatory, is an integral part of those plans. Examples are abundant. Government-industry materials and technology partnerships in Europe include such programs as EURAM (European Research in Advanced Materials), BRITE (Basic Research in Industrial Technologies for Europe), JESSI (Joint European Submicron Silicon Initiative), EUREKA (European Research Coordination Agency), and EPF (European Polymer Federation). In contrast, the U.S. government's Advanced Material and Processing Program, Advanced Technology Program, and Technology Reinvestment Program are struggling to avoid termination by Congress.

As European and Asian firms capture a growing portion of the AMATs markets, the *opportunities and incentives for U.S. firms* to invest and seek entry *will be insufficient to attract capital.* Lenders are likely to view the industry as an unacceptable risk, reinforcing a shortsighted U.S. business perspective that forfeits capital-intensive, distant-payoff industries and their socioeconomic benefits to more patient and farsighted foreign firms.

Access to AMATs

The U.S. government has not acted to prevent the loss of U.S.-based and U.S.-owned AMATs corporations during the shakeout of the 1990s. As a result, *foreign companies own most or all of some segments of U.S.-based AMATs production* (e.g., carbon fiber), and in other segments no U.S.-based production capability remains.

In March 1995, the U.S. government's National Critical Technologies report concluded that "the US is well positioned in those technologies that are deemed critical to the nation's economic prosperity or national security. . . . We must continue to improve both our development efforts and our efforts to diffuse advanced technology widely into the economy and information systems and components used by the military to protect

the nation's security" (Office of Science and Technology Policy, 1995, 161). The size of the U.S. lead has either declined or remained constant, which argues for continued U.S. investment in technology development if that lead is to be preserved.

Similarly, a 1996 DoD report titled *Advanced Materials Technology and the Industrial Base* concluded that in the areas of specialty metals, polymer matrix composites, and ceramic matrix composites the U.S. position is healthy and acceptable. The DOD's future need for metal matrix composites is substantial, but the U.S. AMATs sector is not capable of filling that need. The report concludes that the barriers to entry in this sector cannot be overcome by industry alone.

Based on our review, it is not clear that the U.S. government understands the degree to which the AMATs industry has fallen into foreign control. *A substantial challenge is to conduct an industrywide study to determine in exactly which parts of the U.S. AMATs industry the United States still maintains a significant presence and the impact of those areas that have been taken over by non-U.S. companies.*

OUTLOOK

The real question is whether or not the U.S. AMATs industry is positioned to meet the demands of U.S. commercial manufacturers as well as support national security requirements in the future.

The United States has *a strong human resources and knowledge base* in materials science and engineering, as evidenced by strong undergraduate and graduate university programs in materials, physics, chemistry, and biology. In fact, the United States has more university programs dedicated to materials than any other nation. The United States also is strong in interdisciplinary R&D, as evidenced by the network of Materials Research Labs and Centers of Excellence supported by the National Science Foundation, the DoD, the National Aeronautics and Space Administration (NASA), and other organizations. Traditionally the United States has led not only in materials development but also in their application.

In the area of infrastructure, the United States has *well-equipped labs for characterizing materials and developing processes* and programs that allow the labs to form networks that fully utilize their capacity and grant access to all potential users.

On the other hand, the United States is *weak in capital investment.* Since AMATs research, development, and production are capital intensive, this weakness presents a problem, particularly in the area of materials development. Many U.S. firms that do not have the access to the patient capital necessary to see development through have sold themselves or their materials development groups to foreign firms with more patient capital. For example, the major U.S. suppliers of advanced ceramics are foreign owned.

AMATs are highly *dependent on sophisticated equipment for research, development, and production.* While the United States has many suppliers of such advanced equipment, competition is strong from other countries, namely Japan, Germany, and the United Kingdom. One clear advantage for the United States is the growing use of computer modeling in materials R&D.

Home demand for AMATs in the United States is high and diverse. The United States has some of the most sophisticated and innovative users in the world, but two, the DoD and NASA, are currently in decline. Other industry sectors, such as aerospace, biomedical devices and equipment, electronics, communications, automotive equipment, and computers, continue to push materials development. However, in some of these cases U.S. innovative capability trails that of other countries. For example, Japanese automotive firms often lead the way in the use of new materials.

Near-Term Outlook

U.S. firms are concentrating on core competencies and taking a near-term outlook on their R&D efforts. Large central labs doing basic research are giving way to corporate labs that must support themselves by supporting operating divisions. Private firms are relying more on universities and outside labs for basic research, sometimes supporting that work directly or in cooperation with other industries. This is equally true for materials R&D.

As the industry adjusts to lower defense procurement and commercial applications increase, *extra production capacity has been eliminated or converted.* Over time, the backlog of orders for commercial goods will reduce the industry's responsiveness to fluctuating defense needs.

The AMATs industry must make processing improvements to lower costs and stimulate demand. Lower costs would increase both military and commercial demand and ensure the viability of the industry. For example, slow progress in developing continuous-fiber carbon matrix composite (CMC) and metal matrix composite (MMC) materials is denying both commercial and military users their potential benefits.

The capital-intensive nature of the industry is both a barrier to entry for new competitors and a limitation on existing companies without a differentiated product base. Competition due to overcapacity in component production of AMATs (versus final fabrication) has driven prices to unprofitable levels. In some cases, smaller companies will not survive these pressures on profitability. To justify new production facilities, market demand must increase to raise the value of the materials.

Foreign firms continue to gain ground on the U.S. AMATs industry.

Japanese consortiums are fostering the use of AMATs as a basis for improving processes and strengthening their industry. Foreign ownership of U.S. companies is also increasing. These foreign companies will likely develop unique processing methods and materials that are important to the DoD.

5-Year Outlook

For the most part, AMATs should fit in well with, and in some cases even pace, larger economic and social trends. Furthermore, with adequate investments in R&D the U.S. AMATs industry should be well positioned for the future.

First, not only will *the demand for new and improved materials continue,* but scientific and engineering challenges will continue to grow more complex and provide fertile ground for scientists and engineers. The

innovative capacity of the world economy continues to expand, and there is no reason to believe that it will not continue over the next 5 years.

Economically, the world has seen a *shift in production* over the last 25-30 years. Developing countries have increasingly taken over the large-volume production of standardized products, while developed countries compete in the more flexible and smaller-volume production of specialized products. AMATs, with their tailored properties and processes, fit into the latter category and will continue to be developed for specific applications. Their high-value-added nature will help offset the additional costs associated with them.

Technologically, the trend is *toward smaller scale and greater complexity* (e.g., in microelectronics and biotechnology). Again, AMATs R&D not only has kept abreast of this trend but in many cases has led it. The ability to identify and manipulate individual atoms in the course of processing and to understand the effect of this process on material performance is a major area of materials research.

Politically, the *federal budget will continue to be tight, and government user requirements will continue to decline.* Future technology pull will have to come from the high-value-added, innovative sectors of commercial industry (aerospace, biomedical devices, automotive) that have recognized that materials constitute a strategic technology requiring continuing R&D. This recognition has led companies to maintain relatively stable levels of investments, but it is not clear that they can continue to do so.

Socially, the *desire for a sustainable world economy* is driving the development of cleaner and more efficient use of raw materials. Again AMATs are well positioned to lead this trend. Many AMATs do not require the "smokestack" processing associated with more traditional materials, and many enjoy an adequate supply of relatively cheap inputs (e.g., silica, petroleum products, titanium-bearing ores). The possible exception is in energy content. AMATs tend to be process intensive and, pound for pound, more energy intensive. In addition, recycling efforts tend to lag materials development. Nonetheless progress is being made. Processes have recently been reported that recover "virgin" monomers from used polymers, which have traditionally been

difficult to recycle. In general, new "green" products and processing will lead to new materials.

GOVERNMENT GOALS AND ROLE

The shift away from defense-unique and toward dual-use applications and technologies requires U.S. firms in the AMATs industry to be successful in global commercial markets. As a result, the domestic availability of and access to AMATs and their associated technologies rely increasingly on the industry's ability to penetrate global markets successfully and operate profitably. To do so, the U.S. AMATs industry must build and sustain a competitive advantage in the areas of AMATs research, development, and production deemed critical to the U.S. economy and national security.

As in other advanced technology industries, competitive advantage in AMATs is the result of *proactive policies and regulations that encourage entrepreneurship and generate investment.* This does not imply that the government's role is to provide subsidies or pick industrial winners and losers. Instead, public-private collaboration and consistency in government policies should enable firms to implement globally competitive strategic plans with tolerable levels of uncertainty and risk. More specifically, the federal government can play a decisive role in two important areas: R&D and commercialization.

R&D

In spite of its enormous potential economic and social benefits and well-recognized importance to national security, *public and private investment in AMATs R&D in the United States is declining.* Government funding for AMATs declined from about 3.4 percent of total federal R&D in 1976 to 2.3 percent in 1992. A similar trend is apparent in the private sector. Real R&D spending by bellwether AMATs industries such as aerospace, metals and mining, and chemicals was 3-7 percent less in 1994 than it was in 1993.

Basic research. Government spending should focus primarily on basic vice applied R&D to overcome the reluctance of private firms to invest in areas where long-term returns are not guaranteed and risks are high. Moreover, government funding for national security-related R&D can

stimulate basic research. Defense is still a major user of AMATs for stealth, information, armor, and space applications.

Applied research. Applied research in AMATs should be market driven and shared by government and industry for broad national agendas in such areas as aerospace, telecommunications, and national infrastructure reconstruction. A focus on broad industry areas is more likely to lead to spinoff technologies and to drive advances in education, AMATs, and other areas that would benefit the economy and national security as a whole.

Commercialization

Spanning the areas between basic and applied research is a need to promote the commercialization of new materials and processes. Government programs that once provided critical assistance to the private sector to pursue innovative but capital-intensive and high-risk AMATs projects are struggling to avoid termination by Congress. Without government assistance, many innovative small- and medium-sized AMATs firms are unable to shift their R&D efforts from the laboratory to products in the marketplace. Government investment capital can make a critical difference in these efforts.

Similarly, some material suppliers are exiting the business because of the decline of defense business and low profitability in the commercial sector. The loss of U.S. suppliers means lost development in new technologies, spin-off technologies, and new jobs. The result is a slow erosion of U.S. technological, economic, and military leadership.

CONCLUSIONS

The U.S. AMATs industry is changing. Without a profitable demand for AMATs or direct government intervention, U.S. AMATs companies will reinvest their resources in other endeavors. If current market conditions prevail, commercial U.S. industries such as sporting equipment will continue to use AMATs. However, large-scale applications of the type witnessed in the defense industry will decline, as short-term profitability is at best marginal.

Market forces will continue to drive the industry toward more commercially oriented R&D and products. As in other industries, market forces will continue to influence the demand for and use of AMATs. Without the subsidy of significant ongoing military demand, only those materials that improve performance at an affordable cost will find a lasting niche in the marketplace.

The U.S. AMATs industry still has the technological know-how, capital facilities, and experience to continue to be a global AMATs leader. The current U.S. industrial capability is based on AMATs and associated technologies and processes rooted in national security requirements. With the decline of the defense base, the challenge becomes one of finding a new source of impetus for the industry. Exploration of space and the hydrosphere is an exciting possibility, as is renovation of the national infrastructure.

The United States is reliant on foreign suppliers for some AMATs that are essential for national security systems. Because the United States does not produce all the AMATs used in some military and commercial products, particularly some advanced ceramics and metal matrix composites, Japanese firms are capturing large market shares in several key materials. This trend raises a question of assured access, particularly during periods of crisis.

The DoD should not have difficulty gaining access to AMATs. Despite some concerns, we believe the AMATs industry *can currently support U.S. defense needs.* In spite of the U.S. industry's diminished participation in the AMATs industry, there is no immediate threat to continued access to the AMATs required for military applications. And in the event that world conditions deteriorate, it is unlikely that all allied sources of strategic AMATs would become unavailable for mobilization at any one time.

Breakthroughs into production will require U.S. government support for research and joint activities with U.S. industry. Finally, notwithstanding the availability of AMATs from foreign suppliers, the government must still aggressively support research and joint activities with U.S. industry to encourage production breakthroughs. AMATs are "future materials"

and will ultimately find extensive uses in many defense and nondefense applications. The United States must take a long-term view if it is to be an industry leader when AMATs come into their own.

In view of the conclusions above, the federal government should take the following actions in support of AMATs projects and initiatives:

1. *Forge a positive domestic economic environment conducive to growth and investment.* The federal government can accomplish this through (1) favorable tax policies, (2) accelerated depreciation schedules for capital-intensive equipment, (3) shared government-industry programs and research facilities that focus on shifting AMATs innovations from the laboratory to the marketplace, and (4) trade policies that encourage competition and emphasize fair access to foreign markets.

2. *Protect intellectual property.* The federal government should implement more effective and enforceable policies and patent procedures in order to encourage innovation. Under existing policies, revenue lost to U.S. firms as a result of intellectual property violations will reach an estimated $240 billion by 2000.

3. Identify and evaluate U.S. national security vulnerabilities, military and economic, to foreign advanced material sources or possible technology breakthroughs. The United States needs to preserve and actively support AMATs industrial base areas deemed critical to national security and vulnerable to foreign pressures, loss of access, and industry concentration.

Policies should encourage a domestic economic environment conducive to growth and investment. Such policies require little, if any, additional funding. They do, however, demand long-range vision and plans, private-public collaboration, and consistency and coherence in government policies and regulations. Without a cooperative effort between industry and government, U.S. leadership in AMATS will erode, which will undermine U.S. economic growth in global markets and U.S. influence and power as well.

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ABSTRACT

U.S. agriculture is a $750 billion-plus industry that produces 15 percent of the U.S. gross domestic product (GDP), employs 17 percent of the U.S. work force, and accounts for 13 percent of all U.S. processed goods. These numbers demonstrate the strategic importance of the industry. In today's world, economic wealth is as important as military strength in the calculation of power. The United States is blessed with a favorable climate, abundant resources, and strategic geography, but it is the agriculture business that translates these elements into competitive advantage and, in turn, national power. Because it is an exceptionally productive sector of the U.S. economy, agribusiness makes an important contribution to the nation's wealth.

INTRODUCTION

This report examines the agribusiness sector of the U.S. economy and demonstrates its contribution to U.S. power and security. As a key component of U.S. national power, agribusiness underpins national security. In our studies, we examined the nature of the agribusiness industry, its current condition, the challenges it faces, and prospects for the future. In addition, firsthand observations and discussions with both foreign and domestic agricultural experts gave us a deep appreciation of the agriculture system as a global enterprise. Agribusiness is a U.S. success story; its efficiency and production contribute a great deal to the U.S. GDP. In addition, agribusiness is a very fragile enterprise that in many ways is totally dependent on the whims of nature. The lesson we learned is that agribusiness is an element of national power that the United States must nurture and sustain.

THE AGRIBUSINESS INDUSTRY DEFINED

The agribusiness industry covers broad areas of the economy. It includes the farming sector but is much more than just the traditional "family farm." Agribusiness also includes the food and fiber processing and distribution system as well as the production of other non-food products such as cotton and tobacco. The major sectors of the agribusiness industry are described below.

Suppliers of Farm Inputs

This sector includes suppliers of fertilizer, seed, pesticides, fuel, and farm machinery as well as providers of specialized services, such as credit and information.

Farmers

This sector includes small as well as large operations. Significantly, large farms (those with over $100,000 in gross sales of commodities) are responsible for 90 percent of farm output but make up a very small percentage of all farms.

Processors

Processors perform a wide range of activities, including meat packing, fruit and vegetable canning, and baking --all activities that prepare a raw food commodity, such as grains, vegetables, animal products, and fibers, for consumption. This sector is the major value-added component of the industry.

Wholesalers

Wholesalers distribute food and fiber from primary producers and processors to retailers and food service operations.

Food Retailers

Retailers include both supermarkets and the food service industry. Interestingly, today approximately 45 percent of the U.S. consumer's food dollar is spent on the latter.

Specialty Suppliers

This sector includes technical consultants, biotechnology suppliers, commodity traders, importers, and exporters, all of whom provide a wide range of services that assist producers in growing, distributing, and marketing products.

Exporters and Importers

Internationally, the import-export sector creates a significant positive balance of trade, \$18.9 billion. Total agricultural exports in 1996 will reach \$60 billion, of which \$25.9 billion will be value-added products.

CURRENT CONDITIONS

Trends in Sales

The United States, the world's top exporter of agricultural products, exports to more than 160 countries. The top 10 U.S. markets account for nearly 80 percent of all sales. In 1994, sales to the top 7 U.S. markets increased to record highs. U.S. exports to Japan, the largest U.S. market, increased 5 percent, while sales to Mexico and Russia increased by 11 percent and 30 percent, respectively (Department of Agriculture, 1996, 93). The total value of world trade in agricultural commodities and processed products grew at 8 percent annually from \$65.4 billion in 1972 to \$358 billion in 1994. The United States imports 4.5 percent of its processed food and ranks third in the world in this category. In 1994, the \$43 billion in U.S. purchases of agricultural products accounted for only 6 percent of total U.S. merchandise imports. World trade of processed food increased fivefold and commodities trade increased over fourfold from 1976 to 1996. The economic growth of developing nations and increases in per capita income should continue to expand the global market for U.S. commodities and processed food.

Supports

Agriculture policies encompass diverse goals: economic, environmental, educational, and community development and numerous others far removed from mainstream industrial policy. Many policy goals conflict with one another. Subsidies, which are most often pegged to output, induce farmers to plant too much of what is subsidized and too little of everything else. Excess production pushes prices down; farmers are paid to leave farmland idle in order to push prices back up. In turn, higher prices pinch farm exports, so they too are subsidized. Subsidies have

grown out of control in recent years, approaching or exceeding actual farm net income.

Farm subsidies in the Organization for Economic Cooperation and Development nations now cost around $330 billion each year. This figure does not include the additional billions of dollars consumers pay for food. Based on the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) and the increased need to balance budgets, both the United States and Europe are beginning to move away from the market-distorting methods of agriculture support.

A few years ago a drastic overhaul of U.S. farm policy was thought to be impossible, especially during an election year. However, growing public demand for a balanced budget and the implementing legislation for the Uruguay Round of the GATT have made changes to the current system a necessity. Recent legislation drastically changes the way federal money will be distributed to farmers. First, farm subsidies will cease to be freely spent entitlements. Under the "Freedom to Farm Act" (the 1996 Farm Bill), subsidies will no longer be tied to output. Instead, every participating farmer will be put on a preset, seven-year schedule of declining subsidy payments based on the subsidies each farmer has received. The payment will gradually decrease over the seven-year period to allow the farmer time to compete effectively in the free market. Second, and even more surprising, subsidy payments will be completely detached from what farmers produce. No longer will farmers be required to grow too much or too little of any one crop just to keep their federal subsidy.

With the passage of the Freedom to Farm Act, U.S. agriculture has taken a giant leap towards returning to a free-market economy. Farm subsidies are anticipated to decrease from $10 billion per year today to approximately $6 billion in 1997 and $4.3 billion by 2002. Most price supports and set-asides will also be phased out. In return, farmers will be able to plant any crop they want, in any quantity, or plant nothing at all.

The "Freedom to Farm Act" goes a long way toward breaking the subsidy cycle. The few subsidies that remain--for sugar, tobacco, and peanuts--will inevitably come under heavy scrutiny. The U.S. public is coming to understand that it is paying dearly for the self-imposed inefficiencies of

the U.S. agricultural industry. Eliminating farm subsidies will increase farm productivity, lower the cost of food to consumers, and improve the environment. It is also likely that, once the United States breaks away from farm subsidies, the European Union and Japan will face growing pressure to implement significant reforms.

Productivity Trends

U.S. optimization of land, labor, capital, and management resulted in a steady rise in farm productivity throughout the 1980s and 1990s. The largest productivity improvements occurred in output per unit of labor, feed, seed, and livestock. Farm labor productivity increased 133 percent from the 1982 base; in comparison, labor productivity in nonfarm industries increased 110 percent. Advances in technology; improved farm machinery, fertilizers, and animal health; and economies of scale inherent in larger farms have increased yields while reducing the labor required. Today there are only 2 million farms in the United States, compared with over 13 million in 1910. Fifteen percent of the farms produce 80 percent of the food supply. Advances in technology continue to increase crop and livestock yields.

Biotechnology. U.S. corn yields dramatically demonstrate the importance of biotechnology. After the development of double and single cross-hybrids, corn yields tripled from 40 to 120 bushels per acre from 1960 to 1990. Plant breeders conservatively estimate that at least 50 percent of this increase is due to improved genetics. Better farming methods, equipment, timeliness, and other inputs, such as fertilizers and pesticides, compose the rest (of the gain). Efficient pesticides, such as synthetic pyrethroids, and integrated pest management practices decreased domestic chemical use. Targeted application, reduction in planted acreage, and higher costs resulted in a decline in herbicide use. Fungicide use remains relatively stable.

New technology and management practices have increased beef, pork, and poultry production. For example, feed rations worldwide now routinely have uniform protein, oil, starch, and moisture contents. Somatotropin, a protein hormone produced naturally in the pituitary gland of cattle, increases feed efficiency and milk production and reduces fat content in livestock meat. Health technology has produced vaccines and

therapeutic remedies that reduce livestock disease and the use of antibiotics, but technological gains can also harm the industry. For example, some consumers have expressed concerns about antibiotics in milk and the future use of genetics.

Organizational structure. Mergers, consolidation, vertical integration, competitive networks, and larger farms are changing the organizational structure of food processing and manufacturing. Mergers and acquisitions are causing grain and soybean processing to become more concentrated as a result of mergers and acquisitions; in fact, the 12 largest flour milling firms in the United States produced 67 percent of the flour in 1973 and 80 percent in 1990. The resulting larger, vertically integrated food companies are more capable of supporting biotechnology and information technology than their smaller counterparts are. For example, large poultry and hog processors provide feed, veterinary supplies, management, and technical information in direct contracts with poultry and hog farmers. In the more than 16 percent of large hog farms that today are vertically integrated, a goal is to produce standard-sized poultry and hogs, which makes processing automation easier.

Technology is the key to developing new processing and marketing methods that will boost productivity in the food industry. For example, in 1920 Domino Sugar needed 500,000 employees to refine 2 million pounds of sugar. In 1996, assembly-line improvements such as automation, computer system productivity, and others help 700 employees produce 6 million pounds of sugar a day.

Supermarkets were the primary food distribution system throughout the 1960s and 1970s. Their share of total food sales has steadily declined from a high of 73 percent in 1980 to 30 percent in 1994. Today, the food distribution share is divided among restaurants, supermarkets, and convenience stores, and the fastest growing food retail sector is the fast-food restaurant business. As working families have increased the demand for convenient and fast food, their expenditures for food away from home make up 45 percent of the U.S. consumer food budget, up from 35 percent in 1973.

Profitability

The efficiency of the U.S. agriculture system will continue to keep per capita spending for food products as a share of income low, even after subsidies are eliminated. The farm value of the final consumer product (the farm price before processing, marketing, and retail markup) decreased from 35 percent in 1984 to 24 percent in 1994.

The fast-food industry has become especially profitable. Labor costs are dropping in the fast-food arena thanks to enterprises that reduce the need for labor by using prepared and semiprepared foods. Restaurants have a greater margin of profit than grocery stores. Some large food manufacturers have acquired fast-food restaurants and supplied them with their own processed foods. The fast-food industry continues to grow and in 1996 generates over $60 billion in sales and serves 50 million people daily.

Safety

Food-borne illnesses continue to have a significant impact worldwide. In the United States, millions of people become ill from microorganisms and toxins in food every year. A specific quantification of the effects and costs of food -borne illness is extremely difficult because of the process of reporting illness to authorities and inherent problems in identification of the transfer media. Meat and poultry products remain the most important sources of food-borne diseases. For some, particularly the elderly, young children, and those with depressed immune systems (e.g., people with AIDS), food-borne illness can represent a serious and even life-threatening situation.

The annual cost of foodborne illness in the United States is estimated to be billions of dollars. While it is not possible to eliminate all pathogens from the food supply, modern risk reduction and prevention strategies can significantly reduce the threat of foodborne illness.

Currently, a system of end-product testing, set up in 1938 by the Federal Food, Drug and Cosmetic Act to target agents known to exist at that time, ensures food safety. The U.S. Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA) are considering a

new strategy called the Hazard Analysis Critical Control Point approach to food safety. This system, which relies on in-process evaluation and correction of hazardous conditions, will enable a safer product to reach the market with less government intervention.

Information Technology

Information systems are revolutionizing the agribusiness industry. In retail markets checkout scanners provide direct feedback on consumer demand; computerized systems use electronic price tags to easily change prices and link suppliers, farmers, merchandisers, processors, and retailers. Market evaluations that took months can be completed in days.

Another development in information technology is sensor technology, which reduced cost and increased consumer safety through precisely monitored fertilizer and chemical applications. Large farms use information systems for livestock and crop management, and factories use computerized information systems to (1) produce multiple products based on consumer demand, (2) increase processing, (3) increase productivity, and (4) identify consumer desires. For example, Campbell Soup reduced its production costs by 20 percent, space requirements 30 percent, and inventory 60-70 percent.

CHALLENGES

The U.S. agribusiness industry faces three significant challenges in the coming years: accommodating to the evolving free markets and the globalization of agricultural systems; balancing applied breakthroughs in biotechnology with the need to sustain biodiversity in agriculture, thereby increasing food production without degrading the planet's environment in the process; and dealing with industrial, national, and global food shortages.

Free Markets and Globalization

The increase in the buying power of the emerging worldwide middle- class is triggering an explosion in demand for improved diets. This phenomenon is perhaps best illustrated by the recent skyrocketing of

world prices for grain products, a great deal of which are used to feed livestock.

The long-run prediction for stability for the U.S. agricultural sector is problematic. The questions are: is the current boom in demand a short-term phenomenon? Will the revolutionary changes taking place in the global economy fuel for long-term bull market for agricultural products, thus propelling trade volumes and prices higher for U.S. farmers? Or will the market, flooded by higher production levels, take a downturn and precipitate the collapse of the U.S. agricultural infrastructure, necessitating intervention by the U.S. government once again?

Although the answers to these questions are unknown, all indicators point toward a lengthy period of agricultural trade expansion. The challenge for U.S. agriculture will be to manage risk to sustain its viability and growth over the long term in an increasingly deregulated, global environment.

Biotechnology and Environmental Protection

The world's population is expected to double by 2030 to 12 billion. Some analysts question whether increased food production can keep pace with population growth without seriously degrading the planet's environment in the process. The disappearance of tropical rain forests, wetlands, and other vital habitats will accelerate unless agriculture becomes less taxing on the environment.

Biotechnology has the potential to play a big role in resolving these problems. Genetic research will lead to improved livestock and seed grains, higher protein levels in forage crops, and built-in crop resistance to disease, insects, viruses, extreme temperatures, and even droughts. In addition, biotechnology will make foods healthier and more nutritious.

The ultimate determinant of success for U.S. and world agriculture may be how well farmers manage ever-advancing technologies in ways that increase productivity while protecting the environment. This goal should be within reach of richer countries, but it will present monumental challenges for developing nations, where capital for investment in biotechnology and environmental protection is limited.

A major challenge for the world's agricultural research community will be to find ways to help less developed countries, where poverty frequently causes farmers to jeopardize the health of the environment. Meeting this challenge successfully will require fostering the practice of sustainable agriculture, that is, farming that meets rising demand at economic, environmental, and social costs consistent with rising incomes.

In an increasingly global community, the developing world remains most in need of biotechnology's innovations. However, current research is concentrated on high-value crops grown in the industrialized world. A major challenge will be to find ways to raise incentives and provide technology transfer for farmers around the world in order to better conserve resources while increasing agricultural productivity.

Feeding the Hungry

Despite agricultural advances, the specter of hunger and starvation still hangs over some parts of the world. Some experts are convinced that the major problem resides in Africa and South Asia, where many countries employ marginal agricultural practices and have exploding populations but little or no economic growth potential.

In Africa, which suffers from a poor climate, a lack of public investment in agricultural infrastructure, rural poverty, and governmental corruption, food production is predicted to remain well below the rate of population growth. For example, between 1985 and 1993, crop yields in many densely populated areas of Africa actually fell. Among 41 African countries, yields of cereal declined in 13, and yields of root crops and tubers declined in 15. African farmers, thus forced to abandon traditional farmlands, have resorted to cutting down forests to make room for new planting fields. As a result, Africa loses nearly 12 million acres of forest every year. In South Asia, populations continue to grow at dangerously high rates, while problems with soil degradation and water pollution contribute to malnutrition in many sectors of the population. How the United States and the world community plan to deal with this impending disaster remains to be seen (Paarlberg, 1996).

OUTLOOK

In the global marketplace, a multitude of world suppliers are available to meet the food needs of a nation. Today's nations no longer have to fear that another country will use the withholding of food as a means of pressure. Nations can now achieve food security by using multiple suppliers while focusing their limited resources in areas that will provide them with a comparative advantage in the world economy. The United States, whose geography, weather, and government-industry partnership has permitted it to develop a strategic agricultural industry with a comparative advantage over most nations of the world, must support a policy of food security that assures all nations access to food supplies.

Food's availability or scarcity directly affects a nation's ability to concentrate its political, economic, social, and military energies on its primary objectives (Morgenthau, 1985). As the provider of food domestically and worldwide, agribusiness's ability to support U.S. national interests with the necessary food resources gives the nation the power to influence world events to its benefit. The United States is the world's largest donor of foreign food aid. In FY 1994 and 1995, the United States spent $3.4 billion each year on peacekeeping and humanitarian operations (Institute for National Strategic Studies, *1996*, 134). The U.S. ability to call upon agribusiness to support long-term humanitarian relief operations without affecting its own food consumption demonstrates the strategic role agriculture plays in meeting the nation's objective of maintaining global and regional stability.

World Population Trends

The ability of the United States to affect global stability in the future will depend on the rate of growth of the world's population and the agricultural industry's continuing success in increasing productivity. By early in the 21st century, the world's population is expected to double to 12 billion. Unfortunately, 93 percent of this population growth is expected to take place in regions least able to cope with the increase.

Africa's population is projected to grow from 747 million in 1995 to 1.6 billion by 2025; Asia's, from 3.4 billion to 4.9 billion ; and Latin America's, from 584 million to 794 million. The overall share of

population for developing and underdeveloped countries will increase to 83 percent, while the share of world population for developed nations will decrease from 24 percent to 17 percent.

Demand

Although the world's population is expected to increase, the rate of growth is now declining and is projected to do so throughout the 21st century. During this decline, positive economic growth will continue in the developed and developing nations.. The resulting increase in consumer purchasing power will drive the demand for better diets and higher-quality food products.

As demand for agricultural products continues to rise, competition for market share will intensify as a result of the industry's inability to control prices and profit margins. Companies will increase their market share through efficiency. Farms will continue to increase in size and will consolidate as high-cost farmers drop out. As technology enhances productivity, the resulting decline in labor requirements for agriculture will be offset by increases in employment in food processing, driven by consumer demand.

To meet the demand of the marketplace for increased productivity, the agribusiness industry will continue to consolidate and integrate in the foreseeable future. In 1994, mergers and leveraged buyouts rose for the third straight year, and food processing ranked seventh in the value of mergers among all manufacturing industries. Food wholesaling and retailing ranked second and fourth in their respective industries for a number of mergers in 1994.

Economy

The markets are now responding more to economic signals than to government decisions. Global trends, rising incomes, demand for higher-value, consumer-oriented products, and the spread of the free market system are strengthening the demand for U.S. agricultural products today and will continue to do so into the foreseeable future.

The marketplace is increasingly a global one as agribusiness implements new technologies. Because of these technologies, buyers and sellers around the globe now have almost instantaneous market information and the United States has been able to overcome the economic, political, and social barriers of past trade relationships. The ability to compete on the basis of price, quality, and performance is becoming even more important.

Trade

The demand for exports is projected to expand markets further, continuing the upward trend in U.S. food sales abroad. The result will be additional jobs and income for producers, food processing and transport companies, and associated manufacturing firms.

Of particular interest to the United States is the increase in export of high-value, intermediate, and consumer-oriented products. High-value exports grew to $26 billion in 1994, representing 59 percent of total U.S. agricultural exports , whereas exports of bulk commodities decreased by 5 percent. However, the bulk commodity trend is expected to reverse as the Asian-Pacific Rim economies increase their demand for bulk grain as well as meat products. In addition, of the top 10 markets that account for 80 percent of all U.S. exports, 7--Japan, Canada, Mexico, Taiwan, Hong Kong, the Russian Federation, and Algeria--imported record amounts of U.S. food products in FY 1994. This expansion of the global marketplace has given I U.S. companies an incentive to acquire overseas food-processing businesses. Total sales from these firms are growing faster than exports from the United States, and continued record sales of U.S. agricultural products are expected well into the 21st century.

Technology Improvements

Biotechnology will play a greater role in increasing the productivity of plants and animals by enhancing their efficiency in converting inputs into food and fiber products. Future developments are expected to include products that are drought, flood, and extreme-temperature resistant. Biotechnology will also reduce the use of insecticides and herbicides, make food more nutritious, reduce health risks and groundwater contamination from pesticides, and allow the use of minimum-till agriculture, which minimizes erosion.

The application of biotechnology will also aid developing nations in boosting their agricultural productivity. Based on increasing food demands, the plant biotechnology market is expected to grow worldwide to $2 billion per year by 2000 and $6 billion per year by 2005 ("Plant Biotech," 1995, p. 25).

Another technological source of increases in farm productivity will be farmers use of the information superhighway. For example, in precision farming, which involves linking information about growing conditions to sophisticated, computer-run farm equipment, farmers will be able to treat different areas within a single field and monitor yields during harvesting, all based on computer analysis. Computer modeling will support an increase in dairy production by predicting the genetics for several traits required for a cow to be maximally productive. As the agricultural industry depends more and more on real-time information for decision making, productivity will increase even more and the impact on the environment will decrease.

GOVERNMENT GOALS AND ROLE

Because the products of agriculture are essential to the survival of society, government has a clear stake in the development and advancement of agriculture. Just as agriculture, and the social, economic, and technological factors that surround it, have evolved, the proper roles for government in shaping the direction of agribusiness have changed. To retain the worldwide competitive edge, U.S. public policy toward agriculture must protect the environment, foster research, promote health and product safety, and provide access to world trade.

Environment

In the past, U.S. farm commodity programs that supported eligibility for price and other income support programs encouraged monocultural practices--the production of a certain crop every year on the same land. Studies suggest that monoculture degrades water quality and leads to soil erosion, as it promotes the intensive use of agricultural chemicals and other environmentally unfriendly production practices. In 1992, a national water quality assessment conducted by the Environmental

Protection Agency (EPA) found that the majority of contaminants came from nonpoint, agricultural sources The 1996 Farm Bill partly solves the problem by giving farmers more freedom to farm any crop in the amount they believe will give them the best return. This approach will likely improve agricultural environmental quality by moving farmers away from monoculture.

In 1995, the U.S. General Accounting Office (GAO), after a study of nonpoint source pollution in 618 federally funded, watershed-based projects, reported that a blanket solution to all water quality problems was not effective. The GAO team stressed the need to be flexible in applying pollution control measures in each watershed.

Research

Research, which is more sophisticated and more expensive to conduct than ever before, plays a major role in meeting the challenges facing U.S. agriculture in the coming decade: increasing competitiveness, accommodating the public's demand for safe and nutritious foods produced under environmentally friendly conditions, and increasing productivity of U.S. agriculture. In the past, public funding for agricultural research generated a highly productive and efficient food and fiber sector that has been the key to making U.S. agriculture the most productive and competitive in the world. Only through research will average crop yields increase enough to feed the world's population, which is expected to double by early in the next century.

Agricultural research is a public good because the benefits realized accrue to society. Every tax dollar invested in the U.S. agricultural system has paid back at least $1.35 (U.S. Department of Agriculture, 1996, p. 158). These returns have been passed on to the consumer through lower prices and increased international competitiveness for farmers.

Agricultural research should be accountable in economic terms as well as in terms of its potential effect on the environment and public health. Therefore, publicly funded research institutions should use a systematic, easily understood method of setting priorities. Such a system would allow the full spectrum of biological, physical, and social sciences to collaborate in addressing the impact of research.

Today's agricultural research policies must be linked to policies for health and product safety, the environment, trade, and domestic farming.

Health and Product Safety

Food quality and safety issues challenge both the public and policymakers. Because they cannot judge food quality and safety based entirely on visible characteristics, consumers must rely on the credibility of standards set by the government. The primary food safety concern is whether a particular product causes either chronic or acute health problems. U.S. government policies on health and product safety must establish effective methods of quality assurance. The issue is how and to what standard government should attempt to ensure food quality.

The current system, which spreads responsibility for regulating food safety among several agencies, is problematic. The FDA is responsible for processed foods, meat and poultry are primarily regulated by the USDA, and the EPA determines the legal uses of pesticides and establishes the maximum residue permissible on foods. Essentially, safety standards for processed and unprocessed foods are inconsistent. Whether the United States can establish and implement a comprehensive food policy that includes permanent food quality legislation outside the agricultural framework depends on the strength of special-interest groups, the political organization of congressional committees, and the public.

Trade

The Uruguay Round of the GATT went into effect in January 1995 and is to be fully implemented by 2000. The United States (as well as other signatory nations) was allowed to begin to phase in trade barrier reductions at such high levels that present domestic agricultural policies are relatively unaffected. More important, the successful conclusion of the Uruguay Round cleared the way for negotiations involving 14 other areas of international trade, with benefits to world income anticipated at more than $200 billion. This expected growth may benefit U.S. agriculture as the bulk of the world's consumers--located in the less developed countries--look to add quality, variety, and convenience to their diets.

Determining which programs offer the highest return is becoming more and more important. The question is what the best use of government funds is and how much public and private interests gain or lose from changes in various export market programs. For example, the United States' traditional export strength is in bulk commodities, but those markets are shrinking. The export markets that are growing involve high-value, consumer-ready, and semiprocessed agricultural products., even as budgetary pressures to reduce public funds supporting agriculture will continue.

The federal government should continue to participate in multilateral and bilateral trade negotiations in order to reduce barriers to free trade, including trade in agricultural products, monitor trading partners for noncompliance with the provisions of the Uruguay Round, and seek remedies for violations through the World Trade Organization. The U.S. government should collect market intelligence and make it available to producers and processors. Export promotion programs, to the extent that they are allowed under the Uruguay Round, and credit assistance should target high-value products in emerging markets.

Domestic Farm Policy

Unlike previous farm legislation, the 1996 Farm Bill fixes payments to farmers and decouples those payments from farm prices. Consequently, the cost of farm subsidies should decline from $10 billion a year to about $4 billion a year, according to estimates prepared prior to the passage of the bill. The intent of the new policy is to reduce the impact of agricultural subsidies on the federal budget and allow market forces to determine price and supply. The bill establishes a Commission on 21st Century Production Agriculture that will evaluate how well the new policy supports economic viability in farming by assessing food security, changes in land values, and progress on regulatory and tax relief for agricultural producers. The commission will make recommendations to Congress about the appropriate role of the federal government in agriculture by January 1, 2001.

In our view, to keep U.S. agribusiness ahead in the international arena well into the next century, the U.S. government should (1) continue to

promote global free trade to ensure access to international markets, (2) impose strict environmental regulation within the agricultural sector, and (3) allow for federal government financing of basic and applied agricultural research to ensure high productivity through the next century.

CONCLUSIONS

Today economic wealth is just as important as military strength in the calculation of national power. The United States translates favorable elements of climate, natural resources, and geography into national power. U.S. agribusiness is exceptionally productive and contributes enormously to the nation's economic wealth. The more efficient agriculture is, the more resources become available for other national priorities. Thus, agribusiness strengthens the nation.

However, agribusiness will faces challenges in the coming years. While agriculture now provides a favorable balance of trade, new economic realities such as free trade will force U.S. agriculture to work to maintain its competitive edge. Pressure will come especially from the developing market economies in central Europe and the Commonwealth of Independent States, which have enormous agricultural potential. Another significant challenge is the increasing gap between the developed countries that have an abundance of foodstuffs and the less developed countries, in which people are starving.

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AIRCRAFT INDUSTRY STUDY REPORT 1996

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ABSTRACT

The U.S. aircraft industry is clearly a nationally important strategic industry. Despite a global decline in the industry between 1991 and 1995, most U.S. and international aircraft manufacturers predict a positive future. However, to keep their current 60 percent market share, U.S. companies will have to focus on several key areas in the future. The most competitive global aircraft manufacturing companies are focusing investment and management resources on modernizing and capitalizing on the benefits related to the potential of the computer. And aggressive marketing techniques, such as the use of full-scale cockpit and fuselage mock-ups to demonstrate advanced designs and concepts, appear to be very effective mechanisms for selling aircraft. Despite their current dominance of the global market, we believe U.S. aircraft manufacturers will have to not only aggressively modernize their production and engineering base but also become much more customer oriented to retain their lead.

INTRODUCTION

The study group evaluated the aircraft industry by dividing it into four major sectors--commercial transport aircraft, military fixed-wing aircraft, civil and military helicopters, and aircraft engines--and three key subsectors--design and integration, advanced materials, and avionics/flight controls. Based on research and numerous visits to domestic and international manufacturers, the group assessed the global competitiveness of the U.S. aircraft industry and developed several recommendations for government goals and roles with regard to this strategic industry. We also formulated several recommendations for actions we believe would help the industry help itself in an increasingly competitive global market.

CURRENT CONDITIONS

After steady growth in sales from 1980 through 1990, averaging 3.7 percent annually, commercial and military aircraft sales entered a period of depression because of reduced military expenditures and diminishing demand on the commercial side. In 1995 activity in the aircraft industry

continued to decline overall, with sales diminishing by over 6 percent to $54.5 billion. Sales of civilian aircraft declined almost 10 percent to $23.6 billion while sales in the military sector dipped almost 4 percent to $30.9 billion. Despite the defense drawdown, military aircraft still accounted for 57 percent of total sales (Napier, 1995). However, this share is expected to continue declining as a result of budget pressures and the perception of a reduced threat.

For the third straight year, the U.S. trade surplus declined in 1995. This decline included a 31 percent drop in commercial aircraft exports. However, the aircraft industry is still one of the largest export industries in the United States, with exports totaling $32 billion and an overall positive trade balance of $21 billion.

Aircraft industry employment dropped in 1995 for the sixth consecutive year, falling by 33,000 to 436,000 since the industry's peak employment level of 700,000 in 1989. Overall, jobs in the aircraft industry have been reduced by nearly 38 percent since 1989: 18 percent in the civilian sector and 55 percent in the military sector.

Commercial Transport Sector

The sector defined. This sector includes aircraft capable of carrying 100 or more passengers and similar-sized cargo aircraft. Aircraft configurations include passenger only, passenger and cargo, and pure cargo. Three companies form the major portion of this mature, oligopolistic industry: Boeing and McDonnell Douglas in the United States, and Airbus Industrie in Europe. Entry into the industry by other substantial competitors is not expected because of tremendous start-up, design, and production costs.

Current conditions. Manufacturers must offer a variety of transport models to ensure that they offer aircraft with the capacity to service a wide variety of airline markets as demand grows in the next few years. Manufacturers anticipate strong demand for large aircraft to service Pacific Rim countries, particularly Japan, China, and India, where the potential for additional commercial aircraft sales is great. South and

Central America, along with Africa, represent smaller growth markets in the early 21st century.

Until the end of the Cold War, the buying cycles in the commercial aviation and military segments offset each other. But in the last five years, both sectors have reduced spending, which has led to reduced production and the need for fewer employees. In 1995 the number of production workers continued to fall from its peak in 1989. Current employment in the civil aircraft manufacturing industry is just over 260,000, down from 345,000 in 1991 (Napier, 1995, Table 9). During the last four years sales of civil transport aircraft have declined from over $28 billion to just over $15 billion, or more than 45 percent (Napier, 1995, Table 5). Most of this year's decline was caused by falling exports.

Surge capability is available within U.S. commercial aircraft manufacturers at final assembly facilities. However, of the experienced employees who have previously been laid off, few are now willing to return to the industry because of the cyclical nature of the work. The companies surveyed estimated the average time to produce significantly more aircraft at two years. Additionally, second-tier suppliers would require much more time to develop the additional competent work force and suppliers needed to support substantial surge requirements.

Challenges. Because of the maturity of the commercial transport sector, additional consolidation is probably not possible without creating a monopoly. Therefore, manufacturers are turning to other techniques to further reduce costs and increase efficiencies. For example, the practice of manufacturing component parts internationally is expanding, encouraging global purchasing and easing entry into international markets. Additionally, advanced manufacturing methods help ensure competitiveness in the marketplace. Companies are also expanding the use of computer-assisted design (CAD) and computer-assisted manufacturing (CAM) systems to reduce manufacturing costs and increase product quality. Finally, enlightened companies are emphasizing employee development and training, thereby helping ensure higher-quality processes and products.

Outlook. Aircraft manufacturers forecast an increase in large commercial aircraft orders within the next three years. Replacement of older aircraft that do not meet International Civil Aviation Organization noise and pollution standards is the foremost reason for the increase. Uneconomical flight operations and poor parts support are other reasons for replacing aging aircraft.

Plans for a very large commercial aircraft capable of carrying 600-800 passengers, co-developed by Boeing and Airbus Industrie, dissolved during late 1995. However, we believe future demand requires the development of aircraft of this capacity to continue now, with final design and production delayed until market conditions are more favorable. However, international development of a new large aircraft does not seem feasible at this time.

Military Fixed-Wing Sector

The Sector Defined. As a result of mergers and acquisitions over the past 10 years, the total number of prime manufacturers of military fixed-wing aircraft has declined from eight to four. By 2000 this number is generally expected to be down to only two. Three aircraft manufacturers currently dominate the military fixed-wing market: McDonnell Douglas, with 52 percent of market share; Northrop Grumman, with 27 percent; and Lockheed Martin, with 11 percent (Morracco, 1995, 123).

Current conditions. With sales of military aircraft dropping dramatically (from 497 in 1985 to only 46 in 1996), primary manufacturers and subcontractors continue to scramble to cut costs and manage their overcapacity. The resultant impact on the work force has been devastating. Employment within the aerospace industry has declined steadily since 1987. The military aircraft sector, which saw the biggest cutback, employed 396,000 employees in 1987 but only 169,000 in 1995. An additional drop in 1996 will bring the work force in this segment of the industry down about 60 percent from 1987 levels, to a new low of only 158,000 (Napier, 1995).

To forestall irreversible damage to key areas of the defense industrial base, the Pentagon released over $94 million to Boeing, Northrop

Grumman, and about 45 suppliers to keep the B-2 industrial base warm while planners reexamine future heavy-bomber force requirements. Another proposal is to transfer a greater share of the maintenance and upgrade work from government depots to the private sector.

Challenges. During 1987-95, sales of military aircraft dropped 30 percent, from $44 billion to $31 billion. Projections through 1997 are for a leveling-off at $30 billion. To keep production lines running, military aircraft manufacturers have placed substantial emphasis on the foreign military sales (FMS) market. Unfortunately, the FMS market, the traditional escape valve for military aircraft producers, is shrinking, and the competition for export orders is growing more intense as the number of opportunities dwindles. FMSs of U.S. aircraft plummeted 65 percent from 1992 to 1995, from $1.3 billion to only $460 million (Napier, 1995).

Outlook. As for current fixed-wing military aircraft programs within the United States, Lockheed-Martin's F-16 line will continue in production, but only to support FMS. Lockheed-Martin is also teamed with Boeing to produce the Air Force F-22. The program is slated to receive $2 billion in 1997 and $13.1 billion through 2001 for the initial 40 aircraft, with first flight scheduled for May 1997 and production to begin in 1998. Current plans call for the eventual procurement of 442 aircraft at a projected cost of $72 billion. Both of these contractors are also contenders for the Joint Strike Fighter (JSF). A recent decision by the administration to add one more B-2 to the operational bomber fleet will allow Northrop Grumman to keep that line open as an early test aircraft is refurbished and brought up to operational standards for an estimated $700 million.

Other ongoing programs include a $400 million contract for long-lead items needed to build seven E-2Cs, subcontract work with McDonnell Douglas on the F/A-18E/F, and various modification programs. McDonnell Douglas mainstays include the C-17, F/A-18E/F, T-45, and F-15 FMS. Current plans call for buying 120 C-17s at a rate of 8-15 aircraft per year, as well as 268 T-45 aircraft worth approximately $5 billion. Future F-15 production will continue, but primarily to support FMS programs. The company's largest military program, the F/A-18E/F, will receive $2.6 billion in 1997 for 12 aircraft and $16.9 billion for 150 aircraft through 2001. Production will begin in 1997, and 1,000 aircraft

(including those for FMS) are currently expected to be built, for an estimated program value of approximately $89 billion.

The ultimate prize for the military fixed-wing sector lies in the JSF program. In 1997 the program is budgeted for $600 million, and it is expected to receive $3.8 billion over the next five years. As many as 3,000 aircraft (including FMS) could be produced at an estimated cost of $1 trillion, making the JSF program the largest military aircraft acquisition program ever. Currently the major competitors include Lockheed Martin, Boeing, and a team composed of McDonnell Douglas, Northrop Grumman, and British Aerospace. By the end of 1996, competition will be reduced to only two contractors, who will build prototypes for a fly-off competition. The results will lead to the selection of a final contract in 2000. The first JSF should roll off the production line in 2005. The only other new military fixed-wing aircraft program is the Air Force and Navy's Joint Primary Aircraft Training System (JPATS). Recently awarded to Raytheon Aircraft Co., the 711-aircraft program is expected to be worth $7 billion.

Finally, operational successes with U.S.-built UAVs is drawing increased interest from the military as well as civilian and foreign military markets. Although UAVs currently are not considered direct competition for the military aircraft industry, their future is promising. Rapidly broadening applications and capabilities, along with average unit prices of $3 million to $10 million, are starting to have an impact around the globe as countries weigh the cost and capabilities of UAVs against those of manned aircraft. U.S. contractors producing UAVs include Lockheed Martin teamed with Boeing on the stealthy DarkStar; Teledyne Ryan with the high-altitude, long-range Tier 2+; and General Atomics with the Tier 2 Predator, currently in use over Bosnia. There are many foreign manufacturers of UAVs and, as in the military aircraft industry, competition within the UAV market is expected to be extremely keen.

Helicopter Sector

The sector defined. The helicopter industry consists of military and civil components. U.S. manufacturers include Bell Helicopter Textron, Inc., which makes the Bell Huey, Cobra, and Kiowa Warrior (OH-58) aircraft

and coproduces the V-22 with Boeing Helicopters. Boeing Helicopters produces the CH-47D Chinook cargo helicopter and coproduces the Comanche with Sikorsky. McDonnell Douglas Helicopter Company (MDHC) manufactures the Apache AH-64 (including the Longbow system) and the OH-6 (for special operations units). Sikorsky Aircraft Corporation makes the CH-53 and numerous variants of the UH-60 Blackhawk, while sharing the Comanche production with Boeing.

Foreign countries with helicopter manufacturers include Italy, where Agusta produces models for civil uses and military attack, and medium-utility models for civil and military use. France and Germany cooperatively support Eurocopter, a manufacturer of civil and military helicopters that was formed by the union of the largest helicopter manufacturers in these countries. Under licensing agreements with Sikorsky, McDonnell Douglas, and Boeing, Japanese manufacturers produce UH-60Ls, MD 500s, and CH-47s, respectively. Russian manufacturers mainly produce heavy-lift helicopters. South Korean builders are licensed by Sikorsky to coproduce UH-60P Black Hawks. In the United Kingdom, Westland produces the light-utility Lynx. Westland is also teaming with Agusta on the medium EH-101 and will produce 51 percent of the McDonnell Douglas AH-64s. Westland is licensed by Sikorsky to produce UH-60Ls.

Current conditions. Entry barriers are high because of the costly capital investment, substantial design expertise, and extensive manufacturing capabilities needed for success in this complex business (*Industrial Assessment for Helicopters*, 1995, I-15). Additionally, due to substantial overcapacity within the current manufacturers, it is unlikely that any new helicopter companies will be formed in the foreseeable future.

Challenges. The U.S. helicopter industry today is in a perilous situation. Of the four major U.S. manufacturers, only one has ventured significantly into the commercial arena. The other three are subject to the whims of the Department of Defense (DoD). During the 1970s and 1980s, the military helicopter business thrived on ever-increasing budgets, but now defense funding is rapidly declining along with requirements for military helicopters. Companies such as Sikorsky, Boeing, and McDonnell Douglas will be forced to diversify into the commercial marketplace while

working aggressively to open up foreign markets. We also believe consolidation is certainly feasible and probably overdue. Bell Helicopters is already strongly positioned in the worldwide commercial helicopter market, so DoD budget reductions should only marginally affect them.

Outlook. An examination of DoD helicopter requirements through 2001 reveals that the numbers are dwindling while the value of the lower quantities is actually increasing (*Industrial Assessment for Helicopters*, 1995, III-8). In other words, the cost per aircraft will be significantly higher than for those procured in the early 1990s. The reasons for increasing costs include the low production rate, which drives up unit costs, and the increasing sophistication of the equipment produced today. Although Sikorsky will begin manufacturing the V-22 aircraft in 1997 or 1998, the Comanche program will be the only U.S. helicopter in development after 1997. Until the Comanche enters production in 2003, total U.S. helicopter production will be only 36 UH-60s per year.

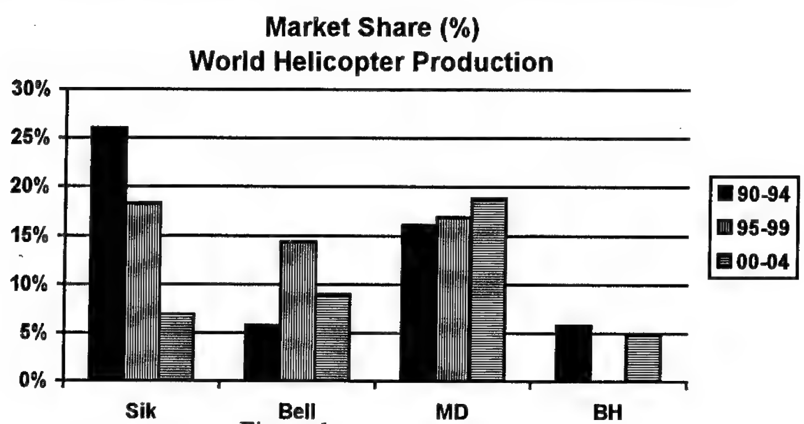

Figure 1

The past and projected global market share in percent for U.S. producers of civil and military helicopters is shown in Figure 1 (*Industrial Assessment for Helicopters*, 1995, II-10). The decline in military helicopter requirements affects Sikorsky more than the other three U.S. manufacturers, as its market share is projected to fall from 26 percent to about 7 percent. MDHC's share actually rises as a result of its production for FMS and its recent aggressive entrance into the civil helicopter sector.

To survive, companies must diversify and compete in the civil market, pursue foreign markets, and seek assistance from the Commerce Department, and consolidate further. Boeing Helicopters and Sikorsky appear to be good candidates for merger because they have substantial overcapacity resulting from vastly reduced production lines and will begin coproducing the Comanche helicopter in 2003. Merging to streamline overhead could reduce costs and produce higher profits.

Aircraft Engine Sector

The sector defined. The global engine sector consists of 18 manufacturers, excluding the nations of the former Soviet Union. Pratt & Whitney (U.S.), General Electric (U.S.), Rolls Royce (UK) and SNECMA (France) account for almost 77 percent of the market share based on installed engines and those currently in production. Numerous second-tier manufacturers provide parts and subassemblies to the industry. High capital costs and complex technology are barriers to market entry (*1995 Aircraft Industry Study Analysis*, 4-21). In 1995, commercial and military engines held 60 percent and 40 percent of the market, respectively (*Aerospace Facts & Figures 1995-1996*, 28).

Current conditions. A buyers' market exists in the commercial sector because of the current excess of aircraft and projected slow sales in the near future. Buyers demand low engine prices, high reliability, and new technology that is cost effective before it earns its way into an engine. Competition among manufacturers is fierce, and profit margins are slim. Firms often sell engines below cost in order to secure market share. Profits from the sale of replacement engine parts typically subsidize losses or very low profits on initial engine sales. However, today's engines require fewer parts and are extremely reliable as a result of improved designs and materials. The once-lucrative spares market can no longer offset expensive research and development (R&D) costs that may take 20 years to recoup (Ropelewski, 1994, 34-37).

Commercial R&D continues to produce affordable and reliable engines at an average industry investment of 3 percent of net sales. Derivative engines are being used to satisfy emerging requirements, such as those for

the Very Large Commercial Transport Aircraft concept. Existing engine configurations are often modified to satisfy higher thrust requirements for new aircraft models as a way of avoiding the long lead times, high cost, and risk inherent in developing an entirely new engine design (Ingrassia and Carley, 1996, 1, 10).

The DoD is funding engine R&D with the Integrated Performance Turbine Engine Technology Program, which focuses on enhanced reliability and maintainability, increased thrust-to-weight ratios, improved fuel efficiency, and reduced weight. In addition, the Defense Advanced Research Projects Agency and the industry are jointly funding R&D in ceramics, organic, metal matrix composites, and intermetallics under the Technology Reinvestment Project (Kandebo, 1995, 55-57; 1994, 63-67).

Challenges. In 1995 sales of civil aircraft, engines, and parts declined 9 percent to $23.6 billion, and sales of military aircraft, engines, and parts declined 3 percent to $31 billion. In 1995, the U.S. aerospace balance of trade was over $21 billion, with aircraft, engines, and engine parts accounting for over $10. billion. The primary tool for countering declining sales and slim profit margins is increased productivity (Napier, 1995, 2). Mobilization surge capacity has also diminished because of the reduced supplier base.

To enhance their competitiveness, U.S. engine manufacturers are increasing productivity and quality; collaborating, merging, or seeking joint ventures to share development costs, risks, and revenue; fostering long-term customer relations; providing buyer financing; exploiting export markets; investing in new product lines to increase top-line growth; and using industrial participation incentives. Additionally, some companies are focusing on providing total product support (combined aircraft and engine sales and aftermarket services in maintenance, training, and spares tracking)and providing engine-lease programs for customers according to hourly usage (Spinker, 1995, 86).

Outlook. Engine manufacturers have a poor record of accurately forecasting the short-term market (Velocci, 1995, 47-48). Nonetheless, for 1996 they forecast a rise of 24 percent or $5.6 billion in the sale of civil aircraft ($5.3 billion for airliners), engines, and parts. U.S. military

aircraft sales forecasts for 1996 are for a $1.4 billion decline (Napier, 1995, 2).

Over the longer term, DoD engine procurements are expected to continue declining with the defense budget. Engines for the C-17, F-22, F/A-18E/F, V-22, and JSF are the only major development and production programs for the future. A derivative engine design is likely to be used in order to minimize the cost and risk of the JSF program. For the period 1996-2013, the commercial sales forecast is an optimistic $200 billion. These forecasts reflect aircraft retirements and traffic growth. One opportunity is for FMSs in Asia: the gross domestic products of Korea, Taiwan, Japan, and China will increase by 94 percent, and their combined economies will total $4 trillion. However, the Asian forecast is subject to change by domestic and international political factors (Kandebo, 1995).

Design and Integration Subsector

The subsector defined. The use of computer design tools is revolutionizing U.S. industry, especially the aircraft industry. Part of the third-wave technology, these tools are evolving into full life-cycle support systems that provide virtual engineering and significantly improved design, test, manufacturing, and modification capabilities.

The use of computer-based design tools has been evolving since the early 1970s, but the industry is now beginning to use an advanced generation of design tools that are capable of providing end-to-end integrated design and manufacturing support. Powerful design packages are now becoming an integral part of the complete process of engineering, design, manufacture, sale, and product support.

The Boeing 777 is the first U.S. example of an aircraft developed exclusively using CAD tools. A computer-based design tool called CATIA was used to develop the entire aircraft, down to the smallest parts. These designs were given to subcontractors in electronic format for manufacture. Using this tool, Boeing was able to build the first aircraft to production specifications, thus skipping the prototype phase and cutting years off of the development time.

Current conditions. Within the aircraft industry, the five major design-tool programs shown in Table 1 currently dominate.

Table 1. Computer-Based Design Systems

Product	Company	Operating System	Clients/ Seats	Customers
Unigraphics	EDS	UNIX	4,500/ 45,000[1]	McDonnell
CADDS	Computervision Corp.	UNIX	180000[2]	Aerospatiale, British Aerospace
CATIA	IBM/Dassault	UNIX	100,000+	Boeing, P& W, GE
CADAM	MICROCADAM, Inc.	Windows	60000[3]	Lockheed
Pro/Engineer	Parametric Technology	Windows NT	9,700/ 15,900[4]	McDonnell

[1] "EDS Unigraphics Announces Record 1995 Results," available from World Wide Web site http://www.ug.eds.com/news/1995rev.html.
[2] Companies & Associations, available from World Wide Web site http://www.bergen.gov/AAST/Computer Animation/CompAn_Associations.html.
[3] *Corporate Overview*, MICROCADAM, INC., available from World Wide Web site http://www.microcadam.com/pages/aboutmi.html.
[4] Parametric Technology Corporation, Company Profile, available from World Wide Web site http://www.ptc.com/mkt/corp_pro.html.

Challenges. The capabilities and costs of these systems vary; single licenses can cost thousands of dollars. All of these products can be described as systems of modules integrated via data exchange. Although data standards are evolving, the exchange of data between different systems is not flawless. Subcontractors are sometimes forced to use the same system as their prime contractor in order to control the risk of noncompliance.

Outlook. The use of "virtual design environments" will continue to increase until products are wholly supported by computer tools that assist in concept development, market strategy, design, manufacture, distribution, maintenance, logistics support, and disposal at the end of the

product's life cycle. Companies that embrace these tools will have a competitive edge.

Advanced Materials Subsector

The subsector defined. Advanced composite materials, including advanced polymer composites, advanced ceramics, and metal matrix composites, are used in both military and civilian aircraft manufacturing. These materials offer improved performance, exceptional strength at reduced weight, durability, and design flexibility (Tortolano, 1994, 70).

Current conditions. Following the pattern established by the B-2 program, military aircraft such as the V-22 and RAH-66 Comanche are being developed with advanced-composite primary aircraft structures (*Industrial Assessment for Helicopters,* 1995, IV-13). As we observed during our visit to McDonnell Douglas, the lessons learned in the area of advanced materials during the development of these military programs, along with the civil Boeing 777 development program, will readily transfer to future applications. However, the industry still does not use advanced materials at their full potential because they are relatively expensive and usually involve complex manufacturing processes.

Until recently the main thrust in developing advanced composites was to increase performance, despite increased manufacturing costs. But recent developments in state-of-the-art machinery have significantly reduced both assembly and inspection times for composite parts. As we saw in visits to McDonnell Douglas, Boeing, and Northrop Grumman, acquisition of automated tape lay-up equipment; unidirectional fiber placement machines; sophisticated ultrasonic inspection devices; large, high-pressure five-axis automated trimming machines; and adaptive control tooling all provide tremendous savings over earlier methods.

Challenges. While composite materials offer numerous benefits to the industry, repairs to damaged composite components are substantially more complex, time consuming, and expensive than on traditional metals. The proprietary aspect of these materials also exacerbates the situation. In partial response, manufacturers are changing their composite designs to place greater emphasis on durability and repairability. Additionally, in an

effort to reduce the financial strain on airlines and to simplify repairs, the Commercial Aircraft Composite Repair Committee is working to develop industry standards for specifications and repair processes (Smith, 1995, 60-61).

Under the U.S. Commerce Department's Materials Technology Subcommittee (Mat-Tec) program, private sector groups form partnerships with government agencies to work out such challenging materials issues as developing subsonic aircraft materials that are affordable and lightweight and high-temperature-tolerant material for engines and supersonic aircraft. Additionally, the groups are involved in developing standards for materials and processes that lower costs and reduce environmental impacts (*The Role of Materials in Global Competitiveness*, 1996, 25).

The reduced availability of advanced titanium alloys, such as Titanium 10-2-3 and Titanium 6-4, which are used extensively in aircraft manufacturing, may harm the aircraft industry in the near future. According to information gained from a visit to Shultz Steel, anticipated high prices, supply shortages, expanding demand for titanium in other commercial products, and suppliers operating at peak capacity will present major challenges to titanium-forging companies as they attempt to keep pace with demand by the aircraft industry.

Outlook. A current goal is to double engine thrust-to-weight ratios, which will require lightweight engines that can operate at extremely high temperatures. Toward this end, titanium matrix composites with ceramic reinforcement are prime advanced-material candidates to replace current metal engine components (Zaretsky, 1994, 124). Improvements in materials and processes can be expected to focus on higher-thrust engines, weight reduction initiatives, improved reliability, and reduction of production processing costs (Directorate of Science and Technology, 1996, 6).

In the future, materials programs for manufacturing will most likely include temperature-cured, toughened thermosets, thermoplastics, bismaleimides, high-temperature thermosets, and titanium composites. As a visit to Boeing demonstrated, future process improvement programs will

focus on advanced fiber placement, improvements in automated composite tape lay-up, unitized and fastenerless assembly techniques, titanium castings and welding methods, high-speed machining, and rate-adaptive manufacturing, such as flexible tooling and nonautoclave curing. The U.S. aircraft industry's supersonic airliner, which has a roll-out target date of 2006, is expected to be produced using new lightweight composites and metallics that are currently under cooperative research with the National Aeronautics and Space Administration (Williams, 1994, 12A(1)).

Avionics/Flight Control Subsector

The subsector defined. Avionics and flight controls comprise the electronic components and systems in civil and military aircraft. The are produced by diverse firms related to the aircraft industry.

Current conditions. Like the aircraft manufacturing industry, the global avionics market has been declining over the past few years. But now it is poised to begin a period of modest growth if anticipated commercial aircraft orders materialize. Growth is also expected in specialized areas such as air traffic control systems, data links, software, and global positioning system (GPS) navigation equipment.

Companies dedicated to the military sector are faced with shrinking markets, ferocious competition, and the lure of less expensive commercial alternatives. However, military aircraft are increasing the content of avionics/electronic systems, which should mitigate some of the effects of the budget decline. The value of avionics components generally equals about 40 percent of the total cost of military aircraft, and avionics are expected to drive as much as 55 percent of the cost of the Air Force's new F-22. According to an Electronics Industry Association analysis, the avionics share of the defense electronics market is predicted to increase slowly from \$5.5 billion in 1996 to \$6.9 billion by 2000. However, this increase will be offset by a steady decline over the same period in R&D funding; the current \$3.2 billion dropping to about \$1.5 billion, where it should stabilize (Nordwall, 1995, 81).

Challenges. Some of the challenges in military avionics are GPS incorporation, sensor data fusion (especially in tactical platforms), and the

increasing economic pressures of tight budgets. GPS navigation systems have been mandated for all platforms by 2000. Data fusion seeks to couple and process information from various sensor inputs to give flight crews a clearer picture of their tactical situation. A system might integrate inputs from passive radar receivers, fire control radar emissions, and infrared sensors to build a target profile for the weapon system. Integration and processing of sensor information highlights the critical role software now plays in military systems. Another impact of data fusion and software growth is the stimulus they provide for using flexible, open-system architecture in the basic system design.

The forces of economics are also formidable in military avionics. A Booz, Allen & Hamilton study on excess capacity reported that in the defense electronics industry today half of the current contractors would have to be eliminated during the next five years to achieve the more efficient capacity utilization rates of the 1987 era (Nordwall, 1995, 83).

Military customers, like their commercial counterparts, are recognizing that affordability must be a key consideration in acquiring new avionics systems and are increasingly trading off some performance for lower cost. One of the impacts of this shift in focus is the use of commercial off-the-shelf (COTS) equipment in military applications. Additionally, defense contractors are now increasingly interested in developing commercial spin-offs of their military systems to capture profits from the much larger commercial market. Many contractors are also adopting teaming arrangements rather than trying to design and produce many products in-house.

Outlook. New orders for commercial airliners mean growth for the avionics industry. Many analysts predict a $1 trillion market for new and replacement commercial transports through 2015, and avionics will account for approximately $1 million of the price of each new aircraft. Additional business equipment, including interactive passenger displays and handsets, could easily add another $1 million of additional electronics to a 400-seat aircraft (Nordwall, 1995, 81). Affordability, long a key consideration in the commercial airline market, is even more influential today. Instead of the previous three- to five-year payback period, airlines

now want payback on their investments in only one year. Technology has to earn its way into commercial aircraft by being cost effective.

One new technology that has gained initial commercial market penetration is the flat-panel liquid crystal display (LCD). The Boeing 777 cockpit incorporated this technology in its initial design, and an upgrade program planned for the Boeing 737 is also installing this technology. Although LCD technology is inherently more reliable than older cathode-ray tube (CRT) displays and can display more information, it is also more expensive. Therefore, while LCD flat-panel displays have achieved some market penetration, they will not dominate cockpit displays until they achieve price parity with CRTs.

Rapid changes in avionics technology create a dilemma for both commercial and military customers: component parts are sometimes out of production by the time the new product is certified and fielded. Using a COTS approach results in lower purchase prices, but often at the expense of long-term supportability. The short life-cycles of some commercial components often dictate two or three major upgrades or replacement programs over the operational life of the aircraft.

OUTLOOK

Civilian aircraft and engine sales are projected to grow by 24 percent, driven by jetliner sales growth of $5.6 billion. While they will not reach the levels of the 1980s, deliveries of commercial aircraft should increase as a result of growing airline traffic and early replacement of older, less fuel-efficient aircraft that will not meet airline fuel efficiency requirements or new stringent noise and emissions standards. Projections indicate a potential commercial transport market of $1 trillion over the next 20 years, with a moderate upturn in the near future and accelerated growth by the turn of the century.

The dynamics of international markets will affect the future of the U.S. aircraft industry. In the 1980s global businesses earned market share through head-to-head competition, and major firms used large-scale layoffs to survive during an extended period of declining sales. As a result, U.S. builders lost over 553,000 seasoned workers, and financial

troubles proved fatal for Holland's aircraft manufacturer, Fokker Inc. (Fuqua, 1995, 3). Today rivals increasingly form teams to share the high cost and risk of new product R&D. Fortunately, industry analysts predict the worst is over.

Traditionally, aircraft sales hinge on the level of passenger and cargo traffic, with healthy economic conditions increasing traffic for airlines and bringing in orders for new aircraft. Economic growth projections for most major regions of the world are positive, as shown in Table 2.

Table 2. Percent Changes in Real GDP, 1974-2014

Region	1974-84	1984-94	1994-04	2004-14
North America	2.5	2.6	2.8	2.7
Latin America	3	2.6	4	3.9
Western Europe	2	2.1	2.5	2.1
Eastern Europe	2.8	-4.4	4.1	4.2
Middle East	0.8	1.5	4.6	4
Africa	2.8	1.4	3.9	4.1
Asia/Pacific	4.6	4.6	4.9	4.5
Former USSR	2.4	-7.3	4.2	3.9
World	2.6	1.8	3.5	3.3

Source: *McDonnell Douglas World Economic and Traffic Outlook 1995*, McDonnell Douglas Corporation, October 1995, 6.

Industry analysts predict that global economic growth will generate requirements for a worldwide fleet of 18,000 passenger and cargo aircraft by 2013. This larger global fleet would require the industry to build almost 14,000 new aircraft: 9,300 to satisfy new demand and the remainder to replace aging aircraft.

Future developments in CAD/CAM should link the machines most subcontractors use to manufacture components with their prime contractor's requirements data base. Additionally, competitive aircraft and component manufacturers will invest in flexible, automated manufacturing and assembly equipment that enables them to easily change projects and accommodate low production runs. Finally, future customers can be expected to continue to base purchase decisions primarily on safety and

performance factors, but "final-quality," full-scale cockpit and fuselage mock-ups could enhance marketability by allowing buyers to see and touch new concepts and product quality firsthand.

GOVERNMENT GOALS AND ROLE

Continued support from the government and changes in some government policies could help ensure the success of the aircraft industry. In response to the dwindling industrial and technological base, we submit eight recommendations for government action:

1. Continue the dual-use approach that merges civil and military practices in technologies critical to both defense and commercial enterprises.

2. Give the industry incentives to invest in high-technology facilities and advanced manufacturing equipment.

3. Promote partnerships between industry and local governments to develop and enhance education and training programs that produce workers with adequate knowledge, skills, and abilities.

4. Continue to review and, where appropriate, reform government regulations and acquisition policies that impose unnecessary and costly environmental, safety, antitrust, trade, and export restrictions.

5. Streamline the government acquisition process by adopting the best commercial procurement and accounting practices.

6. Provide incentives for companies that conduct independent research; then reward pioneering companies by adopting their products, processes, and commercial standards whenever possible.

7. Provide tax incentives for greater capital investment.

8. Reform tax laws to shorten depreciation cycles so that they more accurately reflect today's rapidly decreasing capital equipment life cycle.

CONCLUSIONS

Despite recent declines in the global aircraft industry, most U.S. and international manufacturers look forward to a positive future. During the recent decline, many U.S. manufacturers restructured and downsized their operations to ensure future competitiveness, although we believe further consolidation in the helicopter sector is still needed. However, to retain their current market share, U.S. companies will have to concentrate attention in several key areas.

The most competitive global aircraft manufacturing companies are focusing their investment and management resources on attaining the maximum benefit from the potential of the computer. Computer-based aircraft design, integration, configuration control, and manufacturing are clearly trends that will not abate. Additionally, aggressive marketing techniques, such as the use of full-scale cockpit and fuselage mock-ups to demonstrate advanced concepts and designs, appear very effective in selling aircraft. Despite their current dominance of the global market, U.S. aircraft manufacturers must become much more customer oriented and aggressive in modernizing their engineering and production base to retain their lead.

The following steps by the aircraft industry could substantially improve its success as it faces increasingly stiff global competition in the future:

1. Develop an industrywide strategy for sustainment, growth, and cooperative competition in the global marketplace, with the president of the Aerospace Industry Association leading the effort. Although members of the industry are progressing, they should advance in the same direction by means of a strategy that focuses on sustaining the core capabilities and competencies needed to advance the industry, making every effort to improve its infrastructure, technology, and work force.

2. Support efforts to eliminate artificial barriers to worldwide cooperation and consolidation. We believe the era of protecting U.S. industries from

foreign competition has passed and that emerging markets will create a new paradigm requiring global cooperation and consolidation. We expect the global industry to eventually obscure international boundaries. U.S. companies will continue to thrive if they work together with foreign companies to design, develop, and manufacture aircraft for the future.

3. Expand flexible manufacturing capabilities and exploit programs that allow high efficiency at low volume with multiple products.

4. Integrate independent R&D efforts and, when practical, merge commercial and government-subsidized R&D programs.

5. Continue efforts to automate the design, development, and manufacture of aircraft using computer-based systems. Link prime contractors and subcontractors using CAD tools that reduce the time from design to full production.

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BIOTECHNOLOGY INDUSTRY STUDY REPORT 1996

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ABSTRACT

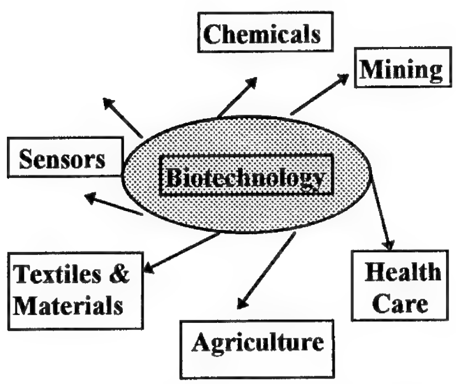
Biotechnology products and processes are revolutionizing the health care, agricultural, industrial chemical, environmental, and other fields. This young, risky, multidisciplinary industry holds endless promise for spin-off products, manufacturing processes in other industries, and sustainability for the future. Biotechnology is niche oriented, geared toward developing high-technology, high-quality, and less expensive products for mankind. Its potential military applications range from biological defenses to new protective materials. The United States leads the world in biotechnology, but the industry is at a critical point in its development cycle and needs continued support for basic research. Just one new discovery can completely change the structure of the industry.

As a result of the biotechnology industry's work, one day in the future a child will receive an AIDS vaccine as a part of her normal pediatric vaccination program, a farmer in Arizona will grow corn in the middle of the desert, and in New Jersey an old industrial site will clean itself for later reuse as a residential area. In the biotechnology industry, the future is limited only by the human mind and financial risk.

INTRODUCTION

The purpose of this report is to describe the applications, condition, and trends of the biotechnology industry against the background of national security requirements and military surge and mobilization needs. To study the industry, we used Caves's (1992) structure, conduct, and performance analysis methodology and Porter's (1990) standards of competitive advantage as appropriate.

THE BIOTECHNOLOGY INDUSTRY DEFINED

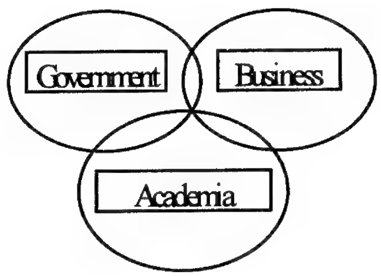


Biotechnology uses living organisms and their products for industrial applications. It combines bioscience principles with multiple current technological disciplines to produce a variety of products and services for society. As the above figure shows, many diverse industries are applying biotechnology as a manufacturing process, and many more will do so as the field gains in experience and knowledge.

Just as the product areas that employ biotechnology are diverse, the industry's structure spans the government, private, and academic sectors. The government has been credited with starting the industry through National Institutes of Health (NIH) grants. Federal and even state government interplay in the industry has been substantial. From funding basic and advanced research to regulating product and process quality standards, the government has a vital role. Universities provide the seeds of new ideas and, through technology transfers, pass innovative projects on to business. Business selects the projects, takes the research through its full development, and finally brings it to the marketplace.

As the figure to the right illustrates, these sectors intertwine because the dynamics of the knowledge base and fluidity of funding sources force close interaction.

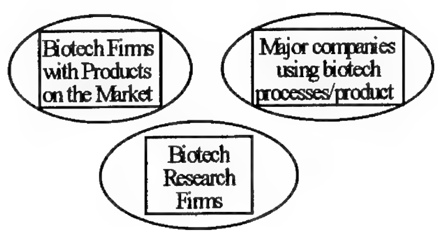
Biotechnology Organizational Interface



Classical biotechnology was first practiced thousands of years ago with the brewing of beer and baking of bread. Yeast acted as the catalyst to alter the organic structure of the compounds into drinkable or edible products. The 1953 discovery of DNA, combined with the recent development of a rapid DNA reproduction process known as a polymerase chain reaction (PCR), changed biotechnology forever. Today, it is a highly sophisticated, collaborative, multidisciplinary scientific field with a fundamental focus similar to that of its ancient predecessor: using living organisms to produce new, enhanced, or less expensive products.

CURRENT CONDITIONS

Biotechnology Industry Structure



Biotechnology formed as an industry in the early 1980s as the growth of small, highly competitive firms drove them to expand their research ideas in focused laboratories. Once its potential captured the interest of financial investors and big business, the industry began to segment into supported product areas. As the above figure indicates, the industry includes biotechnology firms with products on the market (eight companies, such as AmGen, Genentech, Biogen, and Genzyme), biotechnology research firms (such as Advance Tissue, MedImmune, and the Salk Institute), and major corporations in product areas using biotechnology in some portion of their manufacturing processes (for example, Smith Kline Beecham, Novo Nordisk, and Procter and Gamble).

Though a considerable amount of technology is transferred among the segments (since biotechnology processes can be applied to many products), the industry does not lend itself to traditional forms of evaluation. Rather,

the end-product markets greatly dictate the industry's condition. Below we provide an overview of the industry and describe in greater detail the top three market segments, which make up more than 95 percent of today's biotechnology industry.

General

The industry as a whole remains risky as many of the products move from the research into the development phase of their life cycle. Today, more biotechnology products have either reached the market or are quickly approaching it. The all-important survival index of small, medium, and large biotechnology firms has declined. In 1995, these firms had about one-half as many months of operating capital at the average rate of use as they did in 1993, averaging 16 months of operating capital. In addition, as Table 1 shows, the rate at which the industry is obtaining patents remains high but is flattening. Strategic alliance (both national and international) has become a significant form of financing for smaller biotechnology firms. This demonstrates that larger, major firms, which are more risk conscious and business oriented, see great promise for biotechnology in the marketplace.

Table 1. Biotechnology Patent Submissions, 1988-95

Year	Patents	Year	Patents
1988	72	1992	225
1989	115	1993	251
1990	134	1994	250
1991	157	1995	203

Source: Department of Commerce, U.S. Patent Office.

Biotechnology is among the most highly regulated sectors in the U.S. industrial base. The U.S. Food and Drug Administration (FDA), Department of Agriculture (USDA), and Environmental Protection Agency (EPA) multilaterally or unilaterally regulate the quality of products and manufacturing processes. The need for safety and efficacy in its products also places biotechnology among the most research and development (R&D)-intensive industries in the United States. With a $7 billion annual R&D investment that averages $68,000 per employee,

biotechnology's financial payback period must be viewed in terms of many years--possibly two decades. This aspect of the industry makes the role of patents and intellectual property rights protection extremely important in a company's ability to achieve its return on investment (ROI). As noted earlier, the government is an integral player in all facets of the industry.

All segments of the biotechnology industry are sophisticated. Technological processes such as DNA mapping, cell production, protein purification, and gene expression require complicated support equipment and facilities managed and operated by personnel with graduate and postgraduate education. The industry also is linked directly with the information/computer industry, which made possible the complicated algorithms and statistical analyses necessary to identify gene function and location.

The industry's clustering validates Porter's theory of competitive advantage, as a significant number of firms are located in New England, Southern California/San Francisco, and Maryland because the computer industry and major university and government (NIH) centers with biotechnology expertise are located in these areas. The need for close cooperation, information sharing, and virtual integration among biotechnology firms also encourages close proximity. Canada, which has an agricultural cluster in Saskatchewan, further illustrates this logic. All firms gain a competitive advantage from such arrangements.

Overall, the United States clearly leads the world in most statistical indicators for biotechnology (number of firms, dollars invested, value of sales), but other nations have an interest in the industry and possibly advantages in certain niches. Their focus, however, tends to be different. Rather than investing in basic or early applied research, European and Japanese companies have waited until later in the development process to compete, possibly because of more restrictive procedural laws governing biotechnology or government and economic conditions that are not conducive to entrepreneurial firms and venture capital. Nevertheless, foreign companies actively ally with U.S. firms to license technologies or acquire smaller U.S. biotechnology firms. International competition also exists and will likely intensify as new products approach the marketplace.

Finally, the biotechnology industry is not amenable to the use of sales data as a valid measurement of success. To date, only a few biotechnology firms have become profitable, and it is very difficult to obtain sales data on a process industry. Moreover, in many cases, biotechnology serves as a cost-avoidance technique rather than a producer of new-product sales. At this stage, accomplishments with regard to patent and development milestones are better measures of industry status than sales are.

Health Care and Pharmaceuticals

The majority of biotechnology firms and the greatest financial investment occupy the health care and pharmaceuticals segment of the industry. Of the 1,308 U.S. biotechnology firms, about 900, or 70 percent, are in health care-related areas. In addition, 80 percent of federal biotechnology investment goes to health care or related projects. Although sales are not a completely reliable measure of the industry, 1995 sales in this segment were estimated at $8.2 billion. Certain analysts predict 13 percent and 9 percent average annual growth rates over the next 10 years in human therapeutics and diagnostics, respectively.

As shown in Table 2, this segment is characterized by a low seller concentration of many small firms. A few breakthrough firms are market leaders but still do not have sufficient power to affect market dynamics. The soaring growth of biotechnology company start-ups in the 1980s and early 1990s has steeply declined, from 42 in 1994 to only 9 in 1995. The fear of health care reform and price controls may have affected the start-up rate, but the low number of new firms could also be a sign of near seller saturation, investment financiers move away from riskier early research firms and toward applied research companies, or both. Strategic alliances, up 62 percent in 1995, show that the major pharmaceutical firms are now interested in biotechnology companies' products. This interest could significantly affect the structure, conduct, and performance of the industry.

Table 2. Health Care Biotechnology Firms:

Size by Number of Employees and Earnings of Leading Firms, 1995

No. of Employees	Percent of Firms	Firm	Sales (millions of $)
Less than 50	37	AmGen	1,550
51-135	33	Genentech	601
136-299	18	Genzyme	290
More than 299	12	Chiron	276

Source: Ernst & Young, 1995.

Buyer concentration presents a more complicated picture. Many of the smaller biotechnology firms sell intellectual property rights or licenses to produce, and the buyers for such products consist largely of major pharmaceutical firms. The biotechnology firms were able to reap handsome rewards for their intellectual property, but it is unclear whether or not they will be able to continue to do so. Otherwise, the buyers of biotechnology products are either health care professionals or individual patients. In these cases, product differentiation allows the sellers almost to dictate prices.

More than the other segments of the biotechnology industry, the health care segment has focused on new products rather than on improved or less expensive products. To do so, the firms built niches based on staff expertise in immunology, parasitology, virology, and other disciplines. Their focus on niche products, supported by patent protection, gives them a monopolistic capability to set prices for their products. Direct competition among firms exists to a limited degree (being the first to market a product and producing an effective product take precedence)--but it is more the exception than the rule.

At the basic research level, there are almost no barriers to entry, given a highly skilled, technically educated work force. However, carrying a product forward into development calls for significant financial resources. The long FDA approval process requires firms to have substantial staying power (and operating capital) while awaiting their ROI. Also, the need for on-hand manufacturing plant and process prior to FDA approval increases sunk costs. As a result, barriers to entry at the development phase in the product cycle can be extremely high.

Overall, health care and pharmaceuticals remains a risky segment. Only 5 of 4,000 products ever reach the market. The average cost of a new drug exceeds $200 million, and a new vaccine costs over $400 million.

Small firms are reaching a tenuous point in their cash flow: more companies are within one year of exhausting their funds. During 1995, major pharmaceutical companies invested roughly $4.7 billion in smaller biotechnology firms. Without this capital, many companies might not have survived. On the other hand, more biotechnology health care products are in FDA clinical trials than before, with an appropriate growth of products in the later Phase III stage (the top 158 publicly traded health firms have 127 products in this phase, of a total of 450 in trials).

Agriculture

Financially, the agricultural segment of biotechnology is significantly smaller than the health care area. In 1995, approximately 8 percent of biotechnology's $7 billion investment funding went into agriculture. Its projected sales for 1996 were modest at $285 million. At the end of 1995, 10 "agbio" products had received U.S. regulatory approval for commercialization. According to some analysts, this sector has greater potential to expand in terms of product sales than the health care segment does. Robert Fraley, president of Monsanto, believes that the sector will see sales of about $2 billion in five years with another $6 billion by 2005. Other, more conservative analysts predict an average annual growth rate of 20 percent in product sales from $285 million in 1996 to $1.7 billion in 2006. In any case, since agriculture represents 15 percent of U.S. GDP and $40 billion in exports, biotechnology will likely enhance its favorable prospects.

The seller concentration in the agricultural segment began as it did in health care, with numerous small firms. Over time, however, the number of firms declined along with investor enthusiasm. A philosophy of incremental improvement to lower crop production costs and increase yield did not attract investors, so corporate takeovers or affiliations reduced the participants. Today this segment comprises only large chemical and seed companies and a few remaining biotechnology firms. Buyer concentration is also high because farmers, who are not as plentiful as before, are the major customers, not grocery shoppers. This balance between sellers and buyers has made for a relatively even playing field in terms of market and price dynamics.

Definitive economies of scale and high firm concentration preclude the easy entrance of new players. For example, four firms supply more than 60 percent of corn seed. This power gives the firms the ability to set prices below small firms' profit lines or dump for a period to force out the financially weak.

Products are clearly differentiated as traditional and bioengineered crops--the latter carry enhanced survivability while reducing the need for pesticides. These production enhancements, which also lower costs, get farmers' attention, but for the most part they are invisible to the public. Product and process regulation in this segment remains within the purview of the FDA and USDA.

The agricultural segment appears sound and on the brink of profitability. The original biotechnology firms that innovated the ago products, however, will not likely see a return on their investment. Rather, the big seed firms will probably continue their buy-out strategy to ensure that no new competition arises. Because of the continuing population explosion, these firms fully expect a profitable future.

Chemical

The third area of biotechnology that has sufficient maturity to identify a quantifiable production is the chemical community and its product of industrial enzymes. This segment has fewer biotechnology firms and investment--between 4 and 5 percent--but it is the most profitable area today.

The seller concentration for widely used enzymes is high, with two firms dominating over 90 percent of the market. Novo Nordisk, a large chemical-based firm, moved into biotechnology to maintain its leadership role. Genencorp, a start-up biotechnology firm, found the right niche early on. In both instances, these firms acquired others to help them maintain their dominant positions.

Buyers in the chemical segment are highly concentrated because they are also major producers within several industries. Among them are Levi in textiles, Procter and Gamble in soaps, and Kraft in foodstuffs. This concentration makes for a somewhat balanced market arrangement.

Industrial enzymes producers compete against each other because there is only slight product differentiation, mainly in quantity of output. Truer competition occurs in this segment; being the first to patent and market is a key milestone toward success.

Barriers to entry are currently prohibitive to other firms. Novo Nordisk and Genencorp own such a large share of the market and achieve such precise economies of scale that there is no room left for other firms. One $7 billion company abandoned its pilot enzyme program once it realized the size of its competition's share. Until a dramatic breakthrough discovery occurs, this market belongs to the two firms.

Biotechnology within this segment was incorporated as a mainstream process, and it has greater potential in the future as new applications become known. Though the smallest in market size, it is the most stable.

Remaining Segments

The remaining areas that have active biotechnology programs, such as bioremediation of waste products and areas, forensics, biosensors for diagnostic purposes, textile fabric enhancement, and mineral extraction, do not yet approach market scale. They represent the next sectors that should break through and should be closely monitored. Some analysts predict a 19 percent average annual growth in product sales between 1996 and 2006 for the specialty areas of biotechnology, including industrial enzymes.

CHALLENGES

Biotechnology's youth and highly technical nature bring many inherent challenges to its success.

Technical Risk

The industry incurs an extraordinarily high technical risk of failure, particularly within the health care segment, for the following reasons. First, although the knowledge base grows daily, scientists have only begun exploring aspects of the human genome, and many proteins have yet to be discovered. Also, work with living organisms raises legal and ethical complexities. Third, the business must creatively coordinate multiple disciplines to identify, develop, and manufacture a product. .Finally, the government enforces safety and efficacy standards that severely restrict product-to-market ratios. All of these factors make biotechnology heavily R&D oriented, a signal of high technical and financial risk.

Financial Risk

The financial risk for the biotechnology industry is about as high as the technical risk, because very few stand-alone biotechnology firms have made a profit. They still thrive on borrowed money in many different forms. Government grants, venture capital, initial public offerings, and corporate partnerships are all mechanisms for obtaining financial capital, but it can cost hundreds of millions of dollars to bring a product to market in this highly regulated field. The survival index (months of available cash on hand) is low, and smaller firms in the health care segment are at serious financial risk. Many have only one or two products in the pipeline, and if the FDA denies approval of the products, the firms have no reserve. If they survive this stage, they must still survive the possible acquisition plans of major firms trying to consolidate their market position. The small firms thus have a difficult near-term future.

Ethical, Legal, and Social Issues and Public Awareness

Another challenge for both government and industry lies in the ethical, legal, and social implications of certain biotechnology research paths and products. In some areas, the science is outpacing the policymakers' ability

to gauge community standards and ensure the protection of individual rights and privacy. While detection of certain birth defects in unborn children has become widely accepted and commonplace, positive genetic engineering of embryos for certain desired characteristics (e.g., eye color, sex, height, and intelligence levels) has not yet been addressed by policymakers. Issues surrounding insurance companies and employers use of information gleaned from testing for genetically inherited diseases and conditions, such as Huntington's disease and breast and ovarian cancers, are already on U.S. lawmakers' agendas. Procedures developed in the future could cause an upheaval in the U.S. ethical, legal, and social fabric. This problem is compounded by the public's lack of understanding of biotechnology.

The challenge is twofold: industry must act responsibly and cautiously and market itself to gain public trust, and federal policy and legislation need to anticipate issues and appease potential fears. Several European countries have enacted laws, for example, ensuring nondiscrimination by health and life insurance companies on the basis of genetic information.

Regulatory Matters

The FDA has been under constant pressure to reform its procedures and improve the timeliness of the drug approval process. The industry wants greater consistency, consumer advocacy groups want shortened approval times, and the federal government wants reduced health care costs. The FDA's current efforts to reduce the backlog include the critical-product designation, which places a higher priority on certain products, and the pilot test on charging user fees as a way of funding additional staff. While these efforts represent some progress, they will probably not satisfy the interest groups.

Biotechnology lobbyists have a bill in Congress that would (1) contract out product reviews, (2) eliminate the approval process for standard medical devices, (3) allow the export of non-FDA-approved items to foreign countries that accept the products, and (4) harmonize FDA standards with international standards. In the end, the FDA will be forced to further streamline operations without losing its purpose of approving high-quality, safe products. A more "risk-based" model with greater predictability rather than individual evaluator interpretation may grow out

of the effort. In any case, the changes will significantly affect biotechnology.

Continued Supply of Well-Trained Workers

This sophisticated industry requires a highly educated and trained work force. However, educational trends in the United States point toward a decline in students' knowledge of sciences, and an NIH study concluded that only 20 percent of Americans have sufficient knowledge of scientific terms and procedures to understand research vital to their own health. As for knowledge of biotechnology itself, a Minnesota school system poll showed that 78 percent of junior high and 55 percent of high school science courses did not contain a biotechnology module. The FDA's standards for good laboratory and manufacturing practice usually demand a 12- to 18-month apprenticeship.

As biotechnology expands in the future, where will the needed work force, especially at the technician level, come from? The greatest challenge will be in implementing biotechnology education: what should be in the curriculum, how teachers should be trained and retrained, and whether the schools will develop partnerships with industry .

Intellectual Property Rights Protection

Finally, the industry generally relies heavily on the protection of intellectual property rights. Patent acceptance is the first milestone that can lead to financial reward in the form of outside funding and provides the incentive for firms to develop products because they have a better chance of recouping sunk costs with patent protection.

Certain patent issues remain unresolved. For example, serious questions concerning the exhaustion of patent rights and "patent stacking" could compromise aspects of patents' value. Supplemental patent protection may be warranted to offset delays in FDA approval. Implementation of the General Agreement on Tariffs and Trade is critical to the effectiveness of patents and some firms' survival.

OUTLOOK

Because of youth, sophistication, and volatility of the industry and its science, the future characteristics of the biotechnology industry are difficult to predict with confidence. Revolutionary and innovative applications for biotechnology continue to be generated based on a single recent discovery--PCR--and more discoveries are expected in the future.

Near Term (Zero to Five Years)

In the next five years, the biotechnology industry could look much like that of today. Products should continue to move through development and enter the marketing and production phases. Many biotechnology health care firms may still be operating without a profit, but the first profitable year will be just on the horizon. Agricultural firms should realize profits as their newly developed products achieve market acceptance.

The biotechnology industry will also be more prone to employ greater business sense in its practices. New start-ups and older firms will tend to be equipped not just with top-notch scientific staffs, but also with professional business people who can advise firms on better product management and reduction of financial risk. Unrest may grow among market leaders (major pharmaceutical and chemical firms) as the smaller firms start to reach the market. Strategic alliances and buy-outs may increase as a means for the big firms to maintain leadership, which could lead to a reduction in the number of firms doing only biotechnology work. Firms that approach niche markets or outsource into virtually integrated conglomerates will be at lower risk. Efforts to bring about greater public awareness will have begun, with industry and government providing informational references. Public laws addressing biotechnology uses and information could be in place but will not have been fully tested in the court system.

Long Term (to 2020)

We expect that by 2020 biotechnology will be a mainstream element of manufacturing in the world's industrial base. Multiple product lines, including those not yet started, will employ principles of biotechnology. Predicting the conditions of such a young, science-oriented industry,

however, is highly speculative, and analysts disagree in their forecasts. Much of the debate centers on differing assumptions about how mature the industry is today and whether or not it will continue to be highly innovative to 2020.

Analysts who see the industry as maturing today believe that by 2020 a significant reduction of firms will take place--a sign of maturity. Under this scenario, larger but profitable firms will dominate all the traditional biotechnology markets. Universities and small firms will serve R&D roles because their scientific skills and low overhead provide them with a competitive advantage in this area. Major firms will form partnerships with these institutions to keep their competitive edge. Other analysts, however, see the biotechnology industry as still very young, with vast possibilities for breakthroughs and discoveries that could cause numerous new start-ups and product developments. Each new discovery could also generate new stand-alone "survivor" biotechnology companies. These analysts do not see the industry maturing in a classical pattern because of its closeness to its highly scientific roots and the spikes in the industry's development and in the number of firms caused by even small discoveries.

By 2020, public and judicial forums will likely have addressed policy and legislative issues, and biotechnology's role will have been accepted. Health care reform will have occurred, and the FDA will have streamlined its processes. Settling these issues will provide clear signals to the industry and allow firms to make consistent business decisions.

National Security Resource Requirements

Biotechnology undoubtedly will be employed in the production of military hardware. The chemical-biological warfare defense initiative alone has applications in biosensors and vaccine/drug development that use biotechnology. Biotechnology is also used in the military's identification of human remains. General medical, food-processing, textile, and environmental control products are dual-use commodities that have military applications. In addition, energy, advanced materials, and computer technology could easily be using biotechnology processes by 2020. Thus, for the military, biotechnology has strategic importance.

The development of this new industrial base buttresses another pillar in the nation's overall security structure: economic growth. Economic might will be crucial in the next century, so any market segment that enables or substantially contributes to U.S. economic growth must be considered strategic. As a process technology, biotechnology will have a multiplier effect on other industries. A strong biotechnology industry brings growth in financial resources and an elevation of the technology, the quality of employment, and educational bases.

Certainly, the health and quality of life of the U.S. citizen is an important component in the nation's security, and biotechnology shows great promise in this regard. Health care improvements, greater and more secure food production, and less expensive, high-quality products all contribute heavily to the country's welfare.

Finally, biotechnology plays a role in foreign policy that affects the United States' ability to ensure its security. Whether in the form of direct business relations or as a part of foreign aid, the United States can export products and processes from the health care and food production segments of biotechnology that could significantly improve conditions in many troubled nations. In this role, the United States could be seen as a provider of hope and stability.

At the more detailed level of military mobilization and surge, biotechnology does not correct all the problems in the industrial segments it affects, and it may raise new risks in some instances. As a new industry, biotechnology will apply new business management practices that closely size plant capacity, staffing, and inventories to market requirements. As such, the industry is not generally amenable to achieving economies of scale through high-quantity production. Additionally, the FDA approves products to be manufactured only at a certain production rate. Any change requires recertification, which is a lengthy process (possibly over 18 months). As a result, the military cannot expect the industry to carry much excess capacity that could later be filled with mobilization orders. Current technology does not allow for easy switching of products within plants; normally, plants are dedicated to a single product. Over time, greater flexibility is expected, but the current situation limits the ability to surge production when mobilization requires. The industry provides high-quality, high-technology products but does not have the dexterity to

expand quickly. A mobilization deficiency will exist unless the military takes measures to offset purely civilian market factors.

No unusual issues emerge from a review of the military's acquisition system and its interface with biotechnology. As stated, biotechnology heavily emphasizes R&D, and the federal and military laboratory system is currently under close scrutiny. These labs are performing biotechnology research, but the majority is outsourced to businesses and universities.

GOVERNMENT GOALS AND ROLE

The federal government should monitor and, if necessary, assist any industries that are strategic to the nation's welfare. The biotechnology industry falls within this category now and will become even more important in the future. Government actions that will support the long-term health of the industry are described below.

Ethical, Legal, and Social Issues

Federal legislation is required to address biotechnology uses and genetic information. Certain biotechnology research directions, processes, and products could raise explosive issues regarding the nation's social fabric, its values, and even the environment. Such questions include discriminatory use of genetic information by insurance companies and employers, and genetically engineered children. One path is to follow the lead of several European nations, such as Italy, France, and Norway, which have forged national legal positions on the application of biotechnology. The U.S. government should avoid, however, the procedural restrictions in place in many western European nations, especially Germany. These restrictions could cripple the industry and rob the nation of the many benefits of biotechnology.

Targeted Nurturing

As a fledgling strategic industry, direct government funding could greatly help shore up the biotechnology base and foster growth. For example, the government should step in where market forces are not adequate. Venture capitalists have moved into the applied research area, so basic research may be underfunded. The government should maintain a solid stream of

grant funding for basic research through the executive departments. The current tax credits for R&D must continue, but they tend to use sales as a criterion for receipt. Some smaller biotechnology firms may realize that they cannot become producers and therefore revert to pure research concerns, minimizing their sales. The tax credit law could be interpreted or changed to favor these firms.

Sensible Regulatory Reform and International Trade Agreements

The three regulatory agencies that overlap in governing the industry should improve interagency coordination on matters affecting biotechnology companies. At a minimum, a joint committee with members from the FDA, USDA, and EPA could clarify responsibilities and establish consistent guidelines. In addition, trade negotiations and implementation of the resulting agreements are essential for maintaining the integrity of intellectual property rights. Loss of biotechnological property to piracy could devastate the industry. Therefore, the government must remain engaged in protecting intellectual property rights in international trade agreements.

Partnership for an Educated Public and a Well-Trained Work Force

Finally, the government needs to form partnerships with industry to better educate the U.S. public on biotechnology. The effect could be twofold: first, a public that will support biotechnology uses and, second, a technically competent, high-value, basic work force. The state of Wisconsin's model program, which could be emulated on a national basis, includes teacher education workshop programs, hands-on partnerships within science classes, World Wide Web information pages, and a two-year biotechnology associate degree program. A key focus for such programs should be educating future workers at the technician level.

Focused Military Investment and Adjustment to a New Production Process

The growth of biotechnology can significantly benefit the military. If government research grants support the industry's general well-being and state of the art, the military needs to focus on more specific requirements. The military will need to make the cultural adjustment from traditional

R&D and production methods (e.g., for vaccines) to a newer, untested process (e.g., recombinant vaccines). But, on the whole, biotechnology promises better-quality products. At the project or materiel level, biodefense vaccines against biological war agents, human tissue replacement for burn victims, and biosensors for chemical and biological agents are on the brink of development. Military R&D and procurement funding should bring them into the inventory.

Additionally, the military laboratory system needs close scrutiny to validate its usefulness. Its flexibility (that is, whether it has the dexterity to keep up with modern technology) and breadth of focus concern some military customers. We recommend a serious examination of the benefits of having firms compete for or outsourcing some of the research being performed in the military laboratory system.

CONCLUSIONS

Biotechnology is a strategic industry that supports the nation's security and the military's resource mission. This young, process-oriented industry has a multiplier effect because it crosses several traditional product industries in introducing new products, increasing quality, or reducing costs. It provides the nation with economic growth in a new sector while modernizing older industries to give the United States competitive advantages. The industry's economic gains, quality-of-life enhancements, and potential as a foreign policy tool make it a key industry that should receive carefully targeted government support.

Today's industry structure is reaching a crucial point. Smaller firms' financial risk is bringing them to the brink of failure. They are easy targets for cash-rich pharmaceutical, chemical, and seed companies. Larger firms could buy up those firms with "good-potential" products, seriously increasing the seller concentration. On the other hand, new discoveries could cause flurries of start-up companies. Many of the smaller biotechnology firms must decide what their product is: intellectual property rights from R&D or manufactured biotechnology products

The government, in consultation with industry, needs to explore a rational legal framework concerning the uses of biotechnology products and

processes and the information they yield so that privacy and ethical issues do not derail the industry's progress.

The military will benefit from the growth of biotechnology into other disciplines, but the civilian market cannot support all military applications. The military must make wise R&D and procurement decisions to foster those areas most critical to their needs. Most important, biotechnology is not inherently capable of surging for mobilization.

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CONSTRUCTION INDUSTRY REPORT 1996

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ABSTRACT

This report examines the changes in the construction industry--such as design-build contract methodology and privatization of infrastructure--caused by the information systems revolution, economic globalization, and reduced government investments. It explores environmental issues and changing trade patterns in construction machinery and materials caused by the North American Free Trade Agreement. Lessons about terrorism and construction learned from the World Trade Center bombing are also highlighted.

INTRODUCTION

> *The aggregate value of the public works infrastructure in the United States is more than $2.7 trillion. The existence, upkeep and the modernization of this infrastructure are core to our economic competitiveness.*
>
> --Ronald H. Brown, U.S. Secretary of Commerce

The construction industry and its output are important factors in the nation's economic and political power equation. In fact, new construction starts are used to gauge the health of the entire economy. Currently construction spending totals over $850 billion annually. Shrinking government investment in infrastructure may have such a major effect on the industry that the United States will need to seek alternatives to government appropriations for the development and maintenance of infrastructure. Privatization and the concession process, widely used in many countries are possibilities.

In this report we examine the makeup and regulation of the construction industry, the changes that are affecting it, the effects of the globalization of the world economy, advances in networking and information processing, and technical developments in construction materials.

THE CONSTRUCTION INDUSTRY DEFINED

Constructed facilities shelter and support most human activities and directly contribute to quality of life. As such, construction, one of the

nation's largest industries, is a critical asset for enhancing the international competitiveness of U.S. industry. In 1994, new construction and renovation combined amounted to about 13 percent of gross domestic product (GDP) and provided employment for over 6 million workers.

Industry Structure

Construction is a ubiquitous element in the U.S. economy, and its output supports all aspects of life. From houses to roads and water to electricity, construction sustains people and makes their world more comfortable. While the simplest to the most complex technological operations are found in the construction industry, its primary value comes from the *enhanced productivity* of the occupants, owners, and users of construction. The industry involves new construction activities plus maintenance and repair work; the life of a project starts with planning and design, progresses through construction to occupancy and maintenance, and ends with renovation or removal.

Construction is the product of a diverse group of subindustries that involve many individuals and organizations in a single project. The industry includes architects and engineers, contractors and subcontractors, skilled craftsmen and technical specialists, laborers, and equipment suppliers. There are almost 575,000 construction companies in the United States (168,164 general contractors, 37,348 heavy/highway contractors, and 367,762 special trade contractors). Companies range from very small (2-3 persons) to very large (thousands of employees); over 90 percent of construction companies have fewer than 10 employees. Firms generally operate locally or regionally; the largest are international. The largest contractors represent less than 10 percent of all contractor firms but account for about 30 percent of all earnings. Construction is regarded as an industry, but it is more accurately described as a multi-industry sector of the economy. The vision for U.S. construction is to remain competitive worldwide, to continue its lead in quality, and to build efficient and sustainable facilities by *giving customers what they want*

Management: Architects, Engineers, and Contractors

Managing construction projects is a complex endeavor.

Who runs construction projects? Project managers are generally contractors and construction engineers, but architects can also act in this capacity.

How are projects managed? Project management includes managing schedules, tracking goals and milestones, setting baselines, and measuring effectiveness. Projects must carefully adhere to design specifications so that the final product meets the stringent requirements of the building code and owner. Business school graduates rarely enter the construction field, so innovative management practices generally lag behind those being introduced in other industries.

Construction Occupations: The Trades and Skills

What do the workers do? The trades and skilled labor used in construction provide specific expertise for the project. The majority of workers are employed by special trade contractors, and the balance work directly for general or heavy/highway contractor companies. The trades are represented by such skills as *bricklayers, carpenters, electricians, heating and air conditioning specialists, painters, plumbers, roofers, sheet-metal workers, and wrecking and demolition workers.*

Types of Construction

Residential buildings. The residential sector, the largest component of the construction industry, accounted for about 43 percent of the value of construction put in place in 1995 (Table 1). It includes the categories of detached and attached single-family and multifamily homes and other residential buildings, including garages and motels. The largest element within residential construction is single-family detached houses, which account for 29 percent of the value of all construction. In 1995, 1.36 million new housing starts were recorded in the United States.

Private nonresidential buildings. This type of construction, which represents 31 percent of new construction spending, includes commercial buildings such as stores, shopping centers, restaurants, automobile service stations, industrial buildings, office buildings, manufacturing facilities, petroleum refineries, chemical process complexes, electric utilities, hospitals, medical care facilities and institutions, warehouses, and other,

less defined privately owned structures. The largest element of this type of construction is commercial buildings, representing over 9 percent of all construction. Construction of commercial buildings is currently continuing to increase gradually following depressed conditions caused by the overbuilding of office space in the 1980s.

Public works. Public works include construction facilities that support transportation, community life, and government systems, and accounted for about 27 percent of the value of construction put in place in 1995. These works include all types of roads, bridges, tunnels, and associated work as well as educational facilities, public buildings, water and sewer systems, railroads, subways, telecommunications operations, power and communication transmission lines, power plants, pipelines, and military facilities.

CURRENT CONDITIONS

Table 1 depicts both the trend and the outlook for each area of construction spending.

Shrinking *discretionary* budgets and the growing U.S. national debt have combined to reduce per capita funding to support the national infrastructure. Government at all levels is currently spending about $130 billion annually on infrastructure; however, government officials estimate that at least *another $40-50 billion is needed* to maintain the status quo.

Since 1970, private sector construction spending has trended upward in real terms while public sector spending has been virtually flat. Although the U.S. economy and population have grown, investment in infrastructure has lagged behind. Government spending has not maintained a long-range, investment orientation.

Table 1. Value of Construction Put in Place, 1990-99
Billions of 1992 dollars)

Type of Construction	1990 (actual)	1994 (actual)	1995 (estimated)	1999 (projected)
RESIDENTIAL	183.4	217.9	208.2	231.2
Single Family	109.0	126.8	140.3	140.4
Multifamily	19.3	12.8	16.3	15.4
Home Improvement	55.0	64.6	65.2	74.2
[1]	151.6	141.4	148.8	155.4
Commercial	34.3	29.1	32.1	32.2
Manufacturing	23.9	19.6	21.7	23.5
Office	28.8	15.8	17.4	17.6
Telecommunications	9.5	10.5	10.2	12.1
Other	54.9	63.7	64.8	70.1
PUBLIC WORKS	109.0	122.9	129.3	135.2
Highways	33.1	38.6	38.7	45.3
Educational	20.6	21.5	23.3	22.5
Other Public Buildings	17.4	17.8	19.0	20.5
Misc. Public Structures	8.6	11.6	12.8	13.3
Sewer Systems	9.5	10.7	11.0	11.8
Water Supply	4.7	5.6	6.4	6.5
Military	2.7	2.2	2.7	1.8
Other	12.4	15.1	15.6	16.6
TOTAL NEW	444.0	482.2	486.3	

[1]Includes railroads, electric utilities, gas and petroleum facilities, hospitals and institutions, and farm nonresidential construction.

In 1970, the public sector invested almost 2.8 percent of GDP in new construction. Comparable investment today is under 2.0 percent. The difference is a $44 billion annual shortfall.

By comparison, most other industrialized countries invest a higher percentage of GDP in public infrastructure than the United States does; in fact, Japan's investment was roughly triple that of the United States. Because the United States has not invested the requisite funds to sustain the current structure, the U.S. public infrastructure, a key ingredient in future productivity and competitiveness, has deteriorated. If this deterioration is left unchecked, it will adversely affect the national ability to mobilize rapidly in a crisis.

Government Regulation and Law

Federal law: OSHA and Davis-Bacon Act. Numerous government regulations that have a significant impact on the construction industry originate from federal, state, and local sources. Construction contractors often view these regulations as unnecessarily driving up the cost of business.

Several Occupational Safety and Health Administration (OSHA) regulations apply directly to the construction industry. Many contractors would like to see one of them, the General Duty Clause of the OSH Act, eliminated or scaled down, viewing it as an unreasonable and vague hazard abatement standard. Contractors also want OSHA to reward private industry for safety improvement efforts. Many believe that OSHA inspectors need additional training to understand the industry and want OSHA to use trained compliance officials to expose potential hazards in dangerous work environments and not simply issue citations following an accident.

The Davis-Bacon Act was passed in 1931 to ensure that federally funded construction projects paid the "prevailing wage." The effectiveness and cost of this legislation are difficult to evaluate, but the Congressional Budget Office estimates that at current rates of expenditure, the Davis-Bacon Act will add $3 billion to federal construction spending over a five-year period. In addition, 31 states have little Davis-Bacon laws.

Arguments for the repeal of Davis-Bacon include the following. First, the act is excessively complex and cumbersome, and causes a "deadweight loss" (i.e., a loss in economic activity due to administrative costs). In addition, it is logical to believe that the more something costs, the less one buys. Trends in infrastructure indicate that more investment is needed. And it seems preferable to let market conditions rather than the Department of Labor determine wages.

Arguments against repeal include maintaining the stability of the industry in local economies and preventing "traveling" contractors from underbidding projects based upon substandard wage scales.

State and local regulations. Building codes are established to provide minimum acceptable standards in the construction industry. Current standards regulating the home-building industry vary across three large regions of the country, but the U.S. government is promoting a national building code standard to give both domestic and international builders an opportunity to design and produce materials and goods meeting one national standard. Uniform plumbing standards have been established, mechanical standards are near completion, and building standards are slated for completion by 2000. Because lack of uniformity in building codes amounts to a nontariff trade barrier, the move toward uniformity will enhance access to the best materials.

Impact Fees

Land developers have recently been confronted with impact fees, which add significantly to their costs. According to the National Association of Home Builders, impact fees are defined as "charges . . . imposed at some point in the development process, calculated according to a formula and designed to provide infrastructure or services to the development or to ensure the development's contribution to larger scale infrastructure expansions."

Political and legal constraints on traditional funding of infrastructure improvements through property taxes has transferred costs from property owners to land development firms. The fees are charged to support improvements in such infrastructure as roads, schools, sewers, and storm drainage. In California under Proposition 13, impact fees have driven up

the cost of a new home an average of $20,000 because of limitations placed on property taxes. The impact fees are essentially passed down from the land developer to the builder to the new home buyer. In many instances, impact fees slow growth, keep out low-income home buyers, and increase the value of older homes.

CHALLENGES

The Environmental Challenge

Every aspect of the construction industry has increasingly been affected by a wide range of environmental issues. For industry players from the individual homebuilder to the large construction firm designing and building huge commercial structures, the cost of discovering buried hazardous waste or disposing of large amounts of construction or demolition debris becomes higher every year.

Remediation. One of the biggest problems facing developers and builders alike is the burden of site remediation requirements. A well-executed site assessment can often detect contamination, and clean-up costs can be factored into the overall cost of construction. Unfortunately, the cost for the assessment can be quite high-often around $20,000.

The National Association of Home Builders cites costs varying from a low of $2,500 to a high of $8,500 to meet regulations on erosion control, storm water runoff, and tree preservation for each home. Extrapolating the per-house cost to larger developments yields a cost for large construction projects that can run into millions of dollars. In addition, the remediation process is often slow, expensive, and fraught with potential liabilities. Decontamination alone can be extremely expensive, and if hazardous wastes are involved, the costs soar even higher. Excavation disposal of petroleum-contaminated soil costs about $100 per ton and rises to $1,600 per ton for other hazardous waste products (landfill costs can add an additional $300 per ton). Large construction sites often contain thousands of tons of contaminated soil, leading to site remediation costs of millions of dollars. Major projects often experience unplanned remediation problems, resulting in schedule delays and cost overruns.

International opportunities in environmental areas. Tremendous opportunities exist for flexible and innovative construction firms to compete on the expanding world environmental market. In order to compete, U.S. firms must adapt to meet the needs of the international marketplace, but the potential payoff is worth the associated risk. Opportunities are expanding in developing nations in Asia and Latin America for pollution prevention, energy conservation, and waste treatment. The environmental market for five Latin American countries is valued at $2.45 billion a year and is projected to grow 25 percent per year, and the European market will have an environmental market valued at $63 billion per year by the end of this century. Worldwide environmental markets are expected to grow from their current $200-300-billion-per-year markets to $570 billion by 2010. Construction firms that adapt to local customer requirements and team with local firms will be key players in this expanding market.

The Global Challenge

The market. Construction accounts for about 10 percent or more of GDP in many countries. The value of total worldwide construction is approaching $5 trillion a year. The European Union accounts for $1 trillion; Japan, almost $800 billion; and the United States, over $500 billion in new construction. In 1993, U.S. construction contractors, who are strongly competitive in the international construction market, won about 40 percent of the $155 billion in contracts gained by the top 225 international contractors.

The construction business has become increasingly international during the past 20 years. Although only a small number of U.S. construction contractors are active internationally, they are among the most successful in the world. The 12 top U.S. contractors accounted for over 90 percent of the $63 billion U.S. international market in 1994. The U.S. strengths in this market are (1) large-scale design and (2) construction know-how developed from specialized technical engineering projects.

However, U.S. firms must compete in a global market where submitting the lowest bid is the critical determinant of who wins a contract. To be cost competitive, U.S. firms generally enter into partnerships with foreign firms and rely on foreign labor recruited by such firms. Contractors from

developing nations are generally more competitive on low-technology, labor-intensive projects because of their large supply of low-cost labor. Partnering with a U.S. company is attractive to foreign firms because they can obtain experience in advanced construction management techniques and high-technology construction and building systems.

International competition. Global population projections of a growing demand for public works and infrastructure, particularly energy, transportation, communications, and clean air and water facilities, will mean expanding markets for engineering-construction services and capital equipment. The best U.S. export opportunities will be in the fast-growing emerging markets, especially in Asia, where local companies will be unable to handle all the work.

International construction is a big industry in which fewer than half a dozen countries control more than 75 percent of the market. With the exception of the U.S. government, governments in all countries provide varying degrees of support to the construction industry. Export licensing makes it difficult for U.S. firms to ship technology or products to other countries (with the exception of Canada and Mexico), resulting in some lost opportunities.

Financing international projects. Under most systems, tax revenues and government borrowing are the dominant sources of infrastructure finance. Borrowing--whether from official or private sources--is backed by a government's full faith and credit, and thus by its tax powers. Funds for infrastructure projects in developing countries account for the majority of international construction financing.

Increasingly important as a method of financing infrastructure projects is *privatization*. Since the mid-1980s, more than 70 major public purpose, privately financed infrastructure projects, valued at about $30 billion in 14 countries, have been developed. At least 100 other similarly financed projects, with capital costs totaling about $160 billion, are in some stage of development in 33 countries. The Chilean government, which is aggressive in its use of the free-market approach to infrastructure development, offers private developers the opportunity to build and operate roads and collect tolls for 20-year periods and then transfer the facility to the government in virtually new condition. The break-even

period is estimated at 8-10 years on most projects. At the end of the private operating period, the government has the option of operating the system itself or allowing bidders to operate it as a toll road.

This method, commonly referred to as *build-operate-transfer* (BOT), is an alternative method of privately financing a large infrastructure project that would otherwise be paid for with government appropriations. BOT has been utilized on the English Channel tunnel, Buenos Aires' Autopistas de Sol highway, the toll road from Sno Paulo to Rio de Janeiro, and Chile' s major north-south Route 5. The BOT method sends a strong international signal that the country encourages investment and development.

The United States has been reluctant to incorporate privatization; Virginia' s Dulles Airport toll road extension is one of the few projects to come to fruition. In the Seattle, Washington, area, voters rejected a bond measure to improve road and bridge improvements around Puget Sound because they were unwilling to pay the associated tolls. BOT offers the distinct advantage of ensuring that the operator pursues an optimum life-cycle costing solution rather than a low delivery-cost approach to construction projects. The result is an enduring, high-quality construction project serving the public' s best interest. Such efforts can only serve to enhance public confidence in the construction industry.

OUTLOOK

Trade in Construction Machinery and Materials

Machinery. With the globalization of the construction industry, the demand for U.S. products abroad is far greater today than it was a decade ago. The attractiveness of U.S. products is primarily the result of the depreciation of the dollar and lower tariffs. U.S. construction equipment and building materials are especially in demand in Germany to help rebuild the former East German states. We foresee high growth potential as Central Europe pursues infrastructure improvements and development.

The North American market has done well despite minimal growth over the past few years, in part as a result of the North American Free Trade Agreement (NAFTA) among the United States, Canada, and Mexico. The

advent of the world's largest free-trade zone, which encompasses 360 million people and a combined economy of $6 trillion, increased Deere and Company's exports to Mexico and Canada by 47 percent in two years. Construction machinery shipments to Canada and Mexico now account for 10 percent of the total U.S. construction machinery industry. NAFTA removed the tariffs of 15-20 percent on North American equipment sold in Mexico while maintaining duties against Japanese rival Komatsu Ltd. With the world's largest economy and its diversified and flexible manufacturing base, the United States is well positioned to benefit from free-trade pacts.

Nonwood products. U.S. exports and imports of nonwood products are directly tied to the strength (or weakness) of the domestic construction sector. To take advantage of the globalization of the building materials market, the United States and foreign countries are building plants and establishing joint ventures in other countries. In the United States, for example, 65 percent of the cement capacity and 45 percent of the clay brick capacity are foreign owned. Numerous U.S. building material companies are now operating in foreign countries, most prominently in Mexico and Canada, to meet demands there.

The value of U.S. building material exports of nonwood products rose 75 percent between 1989 and 1994 to a record $4.3 billion. The products most frequently exported were flat glass, builders' hardware, fabricated structural metals, plastic pipe and fittings, mineral wool, prefabricated metal buildings, crushed and broken stone, and metal doors and sashes.

The value of imports of nonwood materials rose over 200 percent between 1984 and 1994, totaling over $5.1 billion. The fastest-growing imports were asbestos, cement pipe, concrete block and brick, mineral wool, hard-surfaced floor coverings, crushed stone, and plastic construction materials.

Wood products. The United States remains the world's largest exporter and importer of solid wood construction material. Since 1992, imports have exceeded exports primarily as a result of a strong domestic construction market and reductions in logging in the Pacific Northwest. Exports, however, have remained fairly high because of market globalization and the increased demand for finished wood products.

The increase in U.S. exports of wood products of 160 percent between 1984 and 1994 is attributable primarily to trade with Mexico, to which U.S. solid wood exports increased over 500 percent in value over the past 10 years. Forty-four percent of all wood products exported by the United States go to Japan, however, which remains the leading buyer of U.S. solid wood construction materials. The U.S. wood exporters are targeting the Japanese construction sector because wood structures sustained minimal damage in the Kobe earthquake.

Exports of U.S. solid wood products have experienced steady growth over the past 10 years and are expected to continue to grow. Exports of construction materials experiencing the greatest growth include fabricated structural members (including laminated-veneer lumber and I-beams), hardwood flooring, hardboard, millwork (including moldings, doors, and windows), and hardwood veneer. However, softwood logs and lumber exported to Japan and Korea still make up 46 percent of the total U.S. solid wood products exports.

Imports of solid wood construction materials also increased steadily during the period 1984-94, reflecting a strong residential construction sector and the effects of reduced logging in the Pacific Northwest. Most of the steady growth is represented by imports of softwood lumber, which accounts for 59 percent of imports of wood construction materials. Other wood products that experienced strong import gains during the 1984-94 period were softwood logs, hardwood lumber, hardwood flooring, treated lumber, softwood veneer, and all reconstituted panel products.

Mechanical products. The United States has had a sizable trade surplus in heating, air conditioning, and refrigeration units since 1989. These products are attractive because they are state of the art but not expensive. By 1994, this surplus had grown to $1.8 billion as a result of the demand for high-quality U.S. products, the reduction or elimination of trade barriers, and better exchange rates.

Total U.S. exports in heating, air conditioning, and refrigeration units reached $4.2 billion in 1994, with Canada, Mexico, and South Korea accounting for 46 percent of those exports. Other major customers were Saudi Arabia, Japan, Hong Kong, Taiwan, and Thailand.

Technological Trends

Composite materials and new techniques. Improved technology is the catalyst for change in the industry today. More durable composite materials, such as 3-M polyolefin fibers, increase concrete ductility, toughness, and crack control. DuPont produces composite materials and manufactures rugs from recycled plastic jugs. Hydraulic slip forms and pumps placing concrete from the bottom up are techniques that are speeding up the placement process.

Automation and software applications. Computers are revolutionizing design, management, and marketing in the construction industry. The 4-Dimensional Planner integrates a three-dimensional computer-aided design (CAD) model to produce updated project progress reports. 3-D programs enable buyers to tour a home or airport visually before purchasing one. The industry must embrace new advances in technology to remain competitive.

CAD is radically transforming construction. By encouraging all principals to be involved from the start of a project, new construction design software eliminates the constraints traditionally separating owners, architects, engineers, and contractors. Standardized programs today quickly produce project diagrams that are designed to be understood by a broad spectrum of professionals with different levels of technical expertise and generate building diagrams that can be quickly shared among the owner, engineer, and contractor. The resultant information sharing gives architects and engineers the input on which to base subsequent schematic modifications.

Information management enables companies everywhere to reduce middle management, outsource functions, reengineer processes, and reduce overhead. Networking is changing the face of the industry; new organizations are strategically and instantaneously linking and integrating key players such as designers, suppliers, subcontractors, and consultants into alliances that set the direction of the construction industry.

A striking example of automated data processing is Bechtel-Chile's wide-area network. By tying together design elements for complex proposals in

a very short time, the network gives Bechtel a global competitive advantage and allows the company to aggressively pursue a multitude of projects.

Construction management and delivery systems. Construction management is now emerging as a principal delivery system. It provides the greatest degree of owner advocacy, promotes the team environment, stresses quality and safety, is cost effective, and is compatible with the design-build delivery system. Construction management is increasingly popular and lucrative; Parsons Brinckerhoff has increased its construction management revenue three times faster than its design revenue in recent years.

Improved information systems, new materials, flatter organizations, construction management, and design-build are the by-products of computer application to the construction industry. Traditionally, most construction contracts have delivered products through the design-bid-build system, but owners' demands for aggressive and efficient completion of fast-tracked projects have led to the emergence of a design-build delivery system. Twenty-five percent of all construction contracts in the United States in 1996 followed the design-build system, and the percentage is expected to grow over the next five years. Design-build with modifications will be the favorite delivery system for the industry in the future.

Design-build offers a single source of contractual responsibility to owners requiring fast-tracked project completion, thereby closing the communications gap between architects and contractors, eliminating time lost between design and actual construction, and minimizing the time lag between project conception and completion. Design-build enables the general contractor to focus on the owner's needs and then provide a customized, high-quality product on time to fit those needs. Although design-build may remove some of the checks and balances between the general contractor and the architect, it also eliminates many of the requests for information and communication problems typically encountered with design-bid-build. The integrity of the construction contractor is crucial to the success of the design-build partnership.

A *design-build and construction management mix* merges the speed of design-build with the checks and balances, teamwork, and advocacy of construction management. In this system, the owner, construction manager, architect/engineer, general contractor, subcontractors, and suppliers work as a team from the start to design a functional facility built with affordable and readily available materials. The contract approach of design-build is retained, but a separate construction manager is the owner's advocate in engineering and budget issues.

GOVERNMENT GOALS AND ROLE

Construction and Counterterrorism

In recent years the United States has become the victim of high-profile terrorism, namely, the bombings of the World Trade Center in New York City and the Alfred P. Murrah Federal Building in Oklahoma City. These attacks, coupled with increased incidents of terrorism in Israel, the United Kingdom, and Japan, have generated worldwide concern over the United States' s ability to protect facilities and their occupants. Vehicle bombs are the tactic of choice for terrorist organizations; therefore, protecting a building' s structural integrity from blast effects is an issue of great importance throughout the world.

In response to the threat of terrorism, President Clinton in June 1995, signed Presidential Decision Directive 39, which in part directs the Federal Emergency Management Agency (FEMA) to "ensure that the States' response plans are adequate and their capabilities are tested" with regard to acts "of terrorism directed against large populations in the United States, including terrorism involving weapons of mass destruction."

Despite this threat, in a recent survey of building design professionals, 68 percent acknowledged that they have not changed their design processes or considerations for public or government facilities in the wake of the bombings; the issue of awareness and concern is critical. Terrorism in the United States is no longer an abstract problem. The federal government, in cooperation with various architectural and engineering colleges and universities, professional architectural design and civil engineering

organizations, and various standards and codes agencies, needs to conduct a thorough and practical awareness program to ensure that, where prudent, blast-resistance considerations are incorporated into the design or retrofit of a particular facility or complex.

Recommendations for FEMA consideration:

1. Promote the education of design professionals and construction contractors on the range of measures and considerations that will protect both government and civilian buildings from terrorist activities.

2. Promote a partnership between building owners and the insurance industry that would develop insurance premium compensation packages for those structures and facilities that are hardened and prudently safeguarded from terrorist attack.

3. Promote the utilization of existing technical design manuals, threat-assessment methodologies, and computer-modeling programs developed for military applications with CD-ROM technology; publish and distribute consolidated collections of documents on this subject.

4. Promote the dissemination of these documents and assets to civilian building-design professionals and selected universities and colleges and their engineering and architectural design schools.

5. Promote the development of a comprehensive research and testing program of common building components and materials, assemblies, equipment, and associated designs applicable to the blast-resistant design of critical nonstructural building subsystems.

6. Promote and coordinate a plan for conducting national experimental and analytical studies on the blast resistance of structural subsystems that are typical of design and construction practices in government and civilian buildings.

7. In conjunction with the National Research Council, American Society of Civil Engineers, Association of General Contractors, American Institute of Architects, U.S. Army Corps of Engineers, Defense Nuclear Agency, Naval Facilities Engineering Command, National Institute of

Standards and Technology, State Department, General Services Administration, and other applicable agencies, develop and document the costs for reasonable, low-cost design standards and methods of incorporating blast-hardening and other blast-effect-mitigating features into existing buildings and future construction.

8. Develop as part of FEMA's Internet home page an electronic library of documents readily accessible or attainable by design professionals, security managers, and construction engineers to assist them in locating the myriad documents currently available on blast mitigation and physical security.

CONCLUSIONS

Without its extensive infrastructure of roads, tunnels, sewers, airports, harbors, schools, and reservoirs, the United States would not have developed the advanced economic system the nation thrives on. Whether supporting industrial might or developing minds in the education system, infrastructure assets are strategically vital to maintaining the United States's competitive edge in a global economy.

The construction industry's critical role in maintaining that edge is clear. All indicators point to an ever-increasing need to repair deteriorating transportation systems, to expand and refurbish public buildings, and to increase water and waste treatment capacity. Improvements to almost every category of infrastructure, from such public structures as schools, government buildings, and prisons to the vast transportation network of roads, bridges, tunnels, and airports, are essential.

Expansion requirements grossly exceed the projected availability of public funds. The $130 billion being spent annually on infrastructure is about $40-50 billion below what is required to maintain the status quo. Funding the investment in infrastructure improvements may be difficult, but the United States can ill afford to allow the infrastructure to deteriorate.

The construction industry takes major hits during every recession but continues to show phoenix-like powers of recovery. It supports private citizens, business, all levels of government, and the military infrastructure. It will continue to be called upon during national emergencies.

Construction in the next century will be a global, reputation-based industry composed of organizations that range from several giants offering diversified technical and professional services to many home-based craftsmen. Via computer technology and applications, networks will link subcontractors and suppliers with general contractors, design teams, and even owners. Interorganizational processes will be standard, and contract awards will be based on value. Success will come to international alliances among architects, engineers, and contractor firms in which all parties are committed to improving scheduling and quality and reducing costs. Owners will use construction managers to ensure that the team's goals match the owner's. Design-build combined with construction management will be the primary contracting delivery system. Construction design and materials will continue to evolve and improve in response to terrorist threats; buildings will be constructed to better withstand terrorist attacks, and security improvements will reduce the threat of penetration.

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EDUCATION AND TRAINING INDUSTRY STUDY REPORT 1996

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Organization for Economic Cooperation and Development, Paris, France
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Siemens Factory and School, Berlin, Germany
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ABSTRACT

"Education is society's quintessential act of hope." This is the view of a lifetime educator, Dr. Michael Timpane of the Carnegie Center. However, much needs to be done in the areas of standards development, school-to-work transition, and organizational reform. A well-educated and skilled populace is the cornerstone of U.S. national security and will provide the nation with an enduring competitive advantage. The United States and its children demand and deserve no less than a focus on providing the resources and fostering the climate that will encourage life-long learning.

INTRODUCTION

The future vitality of the United States and its role as a world leader depend on its ability to compete in the rapidly changing, high-technology global economy. The key to this ability lies in the talent, skill, and innovation of Americans in meeting the challenges of the next century. In the international arena, natural resources, capital, and technology are all elements of national power that provide a competitive edge. According to economist Lester Thurow of the Massachusetts Institute of Technology, a well-trained and educated populace provides the only real sustainable competitive advantage (Thurow, 1993). The challenge for the United States is to produce educated citizens armed with the skills necessary for the 21st century.

The purpose of our study was to explore the linkage between the U.S. education system and the social fabric and economic well-being of the nation. We were fortunate to have access to some of the best literature and most authoritative speakers on the subject. Our travels enabled us to observe firsthand the best and the worst of the current U.S. educational infrastructure and, perhaps more important, to meet the tremendously innovative and committed individuals who are working to improve the system. In the words of Father William Cunningham, founder of Detroit's FOCUS: HOPE project, "our children are capable of great things; it is our job to set the standard high and provide them with the opportunity to excel."

We focused on the issues and changes that would permit not only quick improvement but also a long-lasting and positive shift in the U.S.

educational road map. Our study gave us new insight into the problems and challenges facing U.S. education. We believe that the U.S. education system is in need of redirection, resources, and innovation. However, the outlook and the many ongoing efforts are encouraging.

THE EDUCATION AND TRAINING INDUSTRY DEFINED

The U.S. Department of Commerce formally recognizes the education and training industry as a $350 billion enterprise. Given the array of players influencing educational policy in the United States, it is not surprising to find that the education industry is very complex. One way to understand education is to view it as resting on three pillars--school, transition, and workplace.

The *school* pillar consists of the primary and secondary grade levels--kindergarten through 12th grade (K-12). The *transition* pillar, which focuses on transforming high school graduates into productive members of the work force, includes work-study, apprenticeship, community college, and four-year college programs. The *workplace* pillar is training for workers already in the work force.

School Pillar

Elementary and secondary education resides within roughly 15,700 districts, where over 80,000 schools serve over 42 million students and employ over 2.8 million teachers. The nation's 600 largest districts enroll 40 percent of the country's children.

Primary and secondary education in the United States is a government monopoly, offered at no charge to the student. Not surprisingly, public schools educate the overwhelming majority of K-12 students. This level of education is primarily a state and local responsibility, with some federal support for selected programs. Although some funding and management responsibilities reside in individual school districts, each state has the authority to determine academic standards, teacher salaries, certification requirements, curriculum, graduation requirements, and funding levels and to establish choice programs. For most states, public school funding is one of the largest budget items and can result in significant political strife.

Budgetary stresses and competition with other funding measures can limit the amount of funds for education.

Schools are supported primarily by state and local funds. Federal government funding for schools focuses mainly on providing services to educationally disadvantaged children through grants. The federal government provides approximately 7 percent of the funds for public elementary and secondary education; state governments, 46 percent; and local governments, an average of 47 percent (U.S. General Accounting Office, 1995b). In school year 1993-94, expenditures for all public elementary and secondary schools equaled 4.5 percent of gross domestic product, or $285 billion. The national average yearly expenditure per pupil is $5,296.

School districts and parents search for ways to decrease costs and improve performance through a variety of school choice options. One approach is the *charter* school, in which parents take control of the school and its budget, hire the staff, and establish their own standards and procedures. They are exempt from many state and local regulations, are accountable for achieving standards, and can have their charter revoked for poor results. *Magnet* schools usually specialize in advanced or honors programs in a field such as mathematics, science, or the arts in order to attract students from other school zones. Some districts are trying out *contract* schools, public schools that have been turned over to a private contractor to operate, with mixed results. Finally, in an attempt to bring market forces to education, in some districts parents are given *school vouchers* to present as tuition to the school of their choice.

Various departments and agencies of the U.S. government have a role in setting educational policy, ensuring the disadvantaged access to high-quality education, conducting educational research, collecting and publishing information, and providing funds and assistance for education programs. The U.S. Department of Education (DOE) is principally responsible for administering education programs in the school and transition pillars.

Educational reform measures under the Goals 2000: Educate America Act, the School to Work Opportunities Act, and the Improving America's School Act, all enacted in 1993-94, are under the auspices of the DOE.

Other departmental initiatives include promoting partnerships that support greater family participation in education, making college loans easier to obtain, and making schools safer.

Transition Pillar

Over 50 percent of high school graduates enroll in some sort of postsecondary education, but only half of them graduate with a four-year degree. The transition pillar prepares students who do not graduate with college degrees for immediate entry into the workplace. This preparation, which can take several forms, often combines vocational, technical, and other career-oriented training with a standard high school academic program. Many schools, such as vocational-technical (or vo-tech) schools, public and private community colleges, and private training academies, provide some form of transition education.

The U.S. postsecondary (higher) education system, which consists of the community colleges and four-year degree-granting colleges and universities, is vigorous and growing. It is highly diverse, with an array of choices: public and private, secular and religious, specialized and broad based, and large and small. Well financed and very competitive, it is the best higher education system in the world (Reich, 1992, 228). We therefore did not review the higher education system for our study.

Workplace Pillar

U.S. business leaders are finally recognizing lifelong learning as the key to the nation's economic future. New partnerships between educators and employers are gaining momentum. Much of this interest by the business community is profit motivated, for employers bear some of the downstream cost of poor education. It is estimated that businesses spend in excess of $25 billion annually for remedial training and lose another $25 billion in lost productivity (Boyett and Conn, 1992, 271; Kearns and Doyle, 1989, 139).

The U.S. Department of Labor manages several training and service programs, most of which are dedicated to the transition and workplace pillars. Examples include vocational education, school-to-work

opportunities, reemployment services, literacy training, job search assistance, and job training.

CURRENT CONDITIONS

School Pillar

Secretary of Labor Robert Reich writes, "Fully seventeen percent of American seventeen-year-olds are functionally illiterate when they graduate from secondary schools and the average student is ill equipped to compete in the high-value global economy" (Reich, 1992). American children are not as proficient as their counterparts in Canada, Japan, Sweden, and Britain in mathematics, science, and geography. "Only seven percent who complete high school are adequately prepared for college-level science, 60 percent lack reading ability to explain complex information, and 70 percent cannot write an adequate letter" (Reich, 1992). The reading proficiency of 17-year-olds improved slightly from 1971 to 1992 but has not changed since 1988, and writing proficiency declined from 1988 to 1992. From 1969 to 1990, science proficiency declined while mathematics proficiency improved slightly.

At the 1989 Williamsburg Education Summit, President George Bush and the nation's governors agreed that the United States would be unprepared for the scientific, technological, and economic challenges of the 21st century unless it set clear educational goals (*National Education Goals Panel Report*, 1994, 13). The National Education Goals, adopted at that summit, ultimately led to the 1994 passage of the Goals 2000: Educate America Act. In addition to establishing eight goals to achieve in rebuilding the nation's education system, the act also established an independent agency, the Goals Panel, to monitor and report progress toward the goals. Despite some progress, the *Panel Report* indicated that improvement had fallen far short of that required to meet the goals by 2000. Several of the companies we visited, including Motorola, General Motors, and Siemens, validated this finding by expressing their dissatisfaction with the graduates of today's U.S. public schools.

Transition Pillar

Most U.S. high schools are designed to prepare students for college, and most parents assume that their children are college bound. Those students who do not continue on to college enter the work force unskilled and unprepared. Fewer than 1 in 10 U.S. firms hires recent high school graduates (Mendel, 1994, 10). Instead, high school graduates shift casually between jobs, and over 30 percent still are seeking stable employment at the age of 30 (National School to Work Opportunities Office, 1993). This instability has negative effects on individuals, who spend some of their most productive employment years searching for job skills, and on society as a whole, as the delay in achieving economic stability increases the demands on social welfare programs.

Partnerships between school systems and businesses are already making a difference around the country. The partnership between Intel Corporation and a local Arizona high school, which has improved the quality of the school's math, science, and technology programs, was so successful that Intel expanded its involvement to include community colleges in both Arizona and New Mexico. In the words of one executive, it is "in our best interests" (Anfusco, 1995, 128). Intel intends to make sure that the primary and secondary education system does its job, which is to prepare students for meaningful employment as well as for college.

Workplace Pillar

Some of the most innovative and impressive changes in education are occurring in the workplace. Corporate vision combined with a commitment of capital and resources has brought employee training well beyond the on-the-job training so common in U.S. blue-collar industries.

The Motorola Corporation, a world leader in workplace training, commits approximately $120 million annually to remedial and continuation training to Motorola University, a company training and education center. This commitment reflects the importance Motorola places on lifelong learning. The corporate leaders realize that the future competitiveness of the company, and that of the U.S. economy in general, depends on skilled manpower. More U.S. corporations are taking this approach.

CHALLENGES

School Pillar

The basic structure of U.S. schooling has remained remarkably unchanged since the early industrial age, basing itself on the factory model of mass production. The school calendar, however, is agrarian, designed to accommodate the labor needs of the family farm. The system is unreceptive to change, not only on functional and organizational issues but, more important, in the broad areas of curriculum design, standards and performance, and innovation.

There are great disparities in the quality of U.S. education, largely because the methods used to fund education vary from state to state. In addition, the lack of comprehensive and universal standards contributes to the wide range of scores on national tests such as the Scholastic Aptitude Test (SAT).

Investment in technologies that can increase student learning rates is becoming increasingly difficult as funding becomes more scarce. Many schools do not have the technology or infrastructure needed to support learning in the 21st century. In fact, the U.S. General Accounting Office (GAO) estimates that it will cost more than $112 billion to adequately repair, replace, and upgrade the deteriorating school infrastructure (GAO/HHS, 1995, 95-235).

Today, education is losing its priority in state budgets to other public services such as Medicaid, corrections, recreation, transportation, and others. Between 1987 and 1994, the portion of state budgets designated for elementary and secondary education decreased by 11 percent. In contrast, Medicaid's share increased by 90 percent and corrections' increased by more than 10 percent. Less state funding puts a greater burden on localities to generate revenue through property and income taxes.

Currently, nationwide testing determines how much students have learned, but there are no national standards for what students should learn. Although testing is useful in comparing students' achievement among

locations or groups, it does not identify educational goals or measure progress toward achieving them.

Recent trends in U.S. education reveal a leveling-off in per-pupil spending despite increasing enrollments. This trend is generally attributed to a lack of state will in generating and dispersing revenue and to the ever-increasing number of at-risk children in school systems, who are often significantly more expensive to educate than mainstream students.

Support for the much-needed work on raising teaching standards is now surfacing from key unions, including the National Education Association (NEA) and the American Federation of Teachers (AFT). In particular U.S. businesses cite the need for higher standards in the areas of mathematics, science, and team problem solving (Berenbeim, 1993, 10). The NEA and AFT have accepted the responsibility of professionalizing teaching and are willing to accept greater flexibility in hiring procedures, merit pay systems, and new technology in the classroom (Gerstner et al., 1995, 166-69). However, little progress has been made in holding teachers accountable for their product. Until this issue is tackled head-on, little improvement in teacher standards will be realized.

Transition Pillar

U.S. society has come to believe that graduating from college is the only sure path to success. It is time to reconsider this model and construct a path to success for the majority of U.S. high school graduates, who do not earn college degrees.

The transition from school to work begins with the recognition that the student must possess the skills required by the employer. A Bureau of Labor Statistics study found that in 1950 professional and skilled occupations each accounted for approximately 20 percent of the available jobs while unskilled positions made up the remaining 60 percent. Estimates are that by 2000 the breakout will be remarkably altered, with unskilled workers competing for only 15 percent of the job market against a 65 percent share for skilled workers. No more than 20 percent of these jobs will require a college degree.

"It would be wrong to say that the transition between school and the work world is the 'weakest link' in our education and training system; wrong because this assumes there is a link at all" (Mendel, 1994, 7). The United States does not provide a school-to-work transition for the 70-80 percent of young Americans entering the work force without four-year degrees. It has essentially closed the door of optimal productivity on this vast source of human capital (Smith, 1995, 23). This problem and the need for an initial strategy to address it finally received national attention with the passage of the 1994 School-to-Work Opportunities Act (STWOA).

Schools, businesses, and local communities need to develop closer relationships in such forms as mentoring and partnering programs. Teachers would benefit just as much as students from involvement in business partnerships and work programs. Because the majority of today's teachers have never held a meaningful job other than teaching, it may be unreasonable to expect them to teach students about the demands of the business world. A program that places teachers in local companies for at least one year would strengthen the ties between school districts and business as well as create a much broader experience base for teachers.

Workplace Pillar

German businesses recognize the need for lifelong learning and work hard to instill a sense of accountability in both individuals and corporate leaders. Unlike the United States, Germany has established extensive programs that provide employees with opportunities for personal and professional continuing education. The days of meaningful, long-term, profitable employment in "Frederick Taylor-style" mass production in the United States are gone. As the old smokestack industries increasingly give way to modern, technology-driven businesses, inevitably workers will need to overcome their initial reluctance to learning new skills and become more comfortable with a broader range of skills. The world of high technology and rapid change requires U.S. workers to commit to continuous learning to stay productive and competitive. As many as 6 of every 40 work hours in the future may have to be devoted to classroom training and retraining (Boyett and Conn, 1992, 279). Individuals and their employers must accept this and devote the necessary resources to making training available.

According to U.S. Department of Labor projections, individuals will change jobs anywhere from 7 to 10 times during the course of their working careers. Given the fluid nature of the future job market, training new employees will be increasingly costly. Establishing a clear job progression that includes the necessary training at each step will provide workers with a means to improve their standard of living. Business will benefit from more productive employees and reduced expenditures on training large number of new workers. The retention of experienced, highly trained, flexible personnel will be the key to long-term growth in highly competitive markets.

As the post-World War II G.I. Bill emphasized a college education as a way for returning soldiers to reenter the job market, the United States quickly embraced four-year colleges as the guaranteed road to economic security and prosperity. Parents wanted their children to attend college and obtain a degree. Meanwhile, vocational and technical training suffered the stigma of serving only those who could not compete academically at the university level. Unfortunately, less than 50 percent of those who start college actually earn a degree. As a result, tremendous resources are devoted to university education rather than to technical training that is directly applicable to the job market. Teachers, guidance counselors, students, and, perhaps most important, parents need to appreciate the value of skills training and better understand employment possibilities and financial rewards.

OUTLOOK

School Pillar

Since the alarm bell was sounded by *A Nation at Risk* (1983), key leaders have focused on the public school system's deficiencies. States, localities, and individual schools are testing a wide range of new initiatives, including charter schools, magnet schools, contract schools, public school choice, vouchers, extended-day and extended-year programs, and school-to-work programs. Perhaps the most significant emerging player in education is business, which has come to realize that the United States's mediocre K-12 education system hurts companies by increasing their training costs, lowering their productivity and contributing to declining competitiveness.

Alternatives to traditional public education, such as charter schools, have become increasingly popular. They introduce competition into monopolistic public school systems but receive funding at the same levels as other local public schools do. Three years ago only 2 states had charter schools; now 19 states have authorized them.

Although academic proficiency has not progressed much since 1983, there are some bright spots. The percentage of high school graduates taking the courses recommended by *A Nation at Risk* has increased substantially, from 14 percent in 1982 to 52 percent in 1994 (DOE, National Center for Educational Studies [NCES], 1982, 1994). Dropout rates have declined, enrollment in higher education is up, and the percentage of adults with four years of college has increased steadily (DOE, NCES, 1993). In addition, President Clinton recently urged the governors and business leaders at the 1996 Education Summit to develop achievement tests for promotion in elementary, middle, and high school. One way to achieve this goal is through partnerships and mentoring programs. Businesses would then have a direct link to the schools in their districts and could provide feedback to parents, teachers, and students on the skills and abilities needed in future workers.

Because the public generally will not support any initiative that has the appearance of a federal standard, it is very difficult for the federal government to exert leadership in education, no matter how noble the cause. In fact, thousands of school districts as well as the 50 states must reach consensus on educational reform. Another impediment to reform is the teachers' unions, which have been unreceptive to the concept of standards, especially ones that require the measurement of teachers' performance. Perhaps the biggest obstacle to improving education is the ambivalence of parents themselves. If mobilized, a coalition of parents of school-aged children would overcome the resistance to educational reform.

Although education is a state and local responsibility, it is a key element of national strategy, and the workplace badly needs nationally accepted standards. For example, a biotechnician in Texas must have the same skills as one in Massachusetts. Nevertheless, the governors and corporate chief executive officers who attended the 1996 National Education Summit did not support federally mandated national standards and would

oppose anything that appeared to be further federal intrusion into state-controlled education (*National Education Summit Policy Statement*, 1996).

The prognosis for the adoption of national standards in the near future is not encouraging. When Goals 2000 proposed in 1993 that the National Education and Standards Improvement Council approve states' curricula if they matched national standards, the issue devolved into one of the federal government attempting to impose a national curriculum. Although to date there has been little progress in achieving Goals 2000 (Carlson, 1996, 30), the United States must continue to pursue national standards.

Transition Pillar

During our visit to Germany we gained an appreciation for innovative approaches to preparing youth for productive employment. Approximately 70 percent of German high school students enter a vocational system that prepares them for either work or college (Aring, 1993, 398). "One third of German university-trained engineers came up through the nation's apprenticeship system and then attended university, a training program that would be virtually unthinkable for most US engineers" (Marshall and Tucker, 1992, 24).

The state of Maryland now uses a particularly promising model to help students make the transition from school to work. At the end of the 10th grade, students must achieve a basic skill level in reading and writing, validated by a proficiency exam consisting not of a standardized SAT or American College Test but of an essay test of the student's knowledge level. Upon completion of the proficiency exam, students enter a school/work environment where the classroom education is more directly linked to the workplace.

Apprenticeship programs are another way to combine classroom learning with workplace experience while preparing students for a career. Several of the United States's chief economic competitors, such as Germany and Japan, boast advanced apprenticeship programs, and the United States could learn several lessons from them about improving the educational process for the majority of U.S. students who do not attend college prior

to entering the work force. However, other country's models cannot be adopted wholesale because of cultural and institutional differences. One model we analyzed, that of Siemens in Raleigh, North Carolina, is particularly promising in combining math and physics with practical electronics for high school juniors and seniors. Siemens, which has modified the German model to accommodate U.S. values and culture, offers qualified participants a range of factory employment options from direct employment upon completion of the high school program to delayed entry after earning two- or four-year technical degrees at local junior colleges or universities. Summer work experience and scholarships are also available to a limited number of participants.

At Minuteman Technical School in Boston, Massachusetts, the curriculum, organization, and freedom of operation were impressive. This school has a vision of the direction in which U.S. education needs to go, and it is leading the way with innovation and aggressiveness. The school, which has existed for over 20 years, produces impressive results in technical skills development as well as an enviable number of college-bound scholars. Students can choose from virtually any technical, practical, or academic path and receive hands-on training in on-site labs. Students operate the cafeteria, gift shop, and beauty salon and work in construction, auto repair, science, health, and business programs. The most impressive aspect of the school was the students' confidence and direction. Minuteman is much more than a vo-tech school and goes a long way toward dispelling the stigma attached to the concept of vocational schools.

Current legislation will not resolve all of the United States's educational problems, but it can provide the impetus and allocate resources to address some of the significant issues. The STWOA depends on partnerships among businesses, schools, community-based organizations, and state and local governments to bring workplace relevance to school curricula with the ultimate goal of preparing all 16- to 21-year-old students for career-based jobs or further education. The act combines existing apprenticeship, vocational, and cooperative programs with initiatives to form a nationally recognized and accepted system. One of the fundamental aspects of the program is the committed support of U.S. businesses. The partnerships they form with school districts, educators, and students will largely determine the success or failure of the program.

Workplace Pillar

The outlook for dramatic advances in education and training in the workplace is good, and the resources, infrastructure, and top leadership involvement devoted to employee training are impressive. For example, General Motors (GM) in Detroit recently dedicated a new multimillion-dollar training facility. Working hand-in-hand with the United Auto Workers, management and employees have developed required training profiles and personal improvement programs. This cooperative venture has produced more productive employees and improved the relationship between management and the unions. And, as noted, Motorola Corporation has made a substantial, long-term investment in employee training and education. Not all businesses are as progressive as GM or Motorola in the area of employee training, but an increasing number of companies recognize the competitive advantage this type of approach provides.

On the other hand, other businesses lack the vision or the resources required for effective employee training and education. They avoid training expenses by relying on schools and other companies to train their employees (Mendel, 1994, 10), an approach that can lead to high employee turnover and the associated loss of productivity.

GOVERNMENT GOALS AND ROLE

Federal Government

The federal role is bounded by the Tenth Amendment to the Constitution, which grants the states any powers not forbidden by the Constitution or specifically conveyed to the federal government. Nonetheless, the federal government has an important role in establishing broad, overarching policy, providing funds or seed money for a variety of education programs, conducting research, collecting and disseminating information, and ensuring that each state provides equal educational opportunities for all citizens.

Federal leadership is critical for conveying the message to state and local governments, educators, business leaders, parents, and U.S. citizens that

education deserves to be a top priority. The federal government also plays a key national role in advocating educational reform. One example is President Clinton's presence at the 1996 National Education Summit, attended by a consortium of governors and business leaders. Another is the 1996 State of the Union Address to Congress, in which he proposed several new initiatives, among them urging states, communities, and schools to raise educational standards for teachers and students; bringing modern technology into the classroom; providing more public school choices to parents; increasing parent involvement; and expanding access to college.

State and Local Governments

Many states are pursuing such educational reform initiatives as increasing high school graduation requirements, redesigning school funding systems, certifying teachers, and expanding school choice.

At the March 1996 National Education Summit, more than 40 state governors, business leaders representing 49 major U.S. corporations, and education experts made a commitment to developing and implementing high academic standards and content for K-12 public schools, assessing performance, and introducing new technological tools into the public education system. They also agreed to hold schools and students accountable for making improvements (*National Education Summit Policy Statement*, 1996). Federally mandated standards were not recommended.

Recommendations

The federal government should use its leadership role more effectively by establishing a strategic vision and a direction for educational reform in the United States. The federal government must foster the development of national standards for student education and teacher preparation, advocate innovative educational methods through a national dialogue among all education stakeholders, and communicate these educational reform measures while seeking the broadest possible public and congressional support.

The federal government begin by setting the example of lifelong learning within the federal government itself. The executive branch must urge Congress to continue funding educational reform, and the government should provide financial incentives--tax relief, for example--for training and education programs.

Several federal agencies and offices now manage and administer education programs. The federal government should look for ways to streamline and consolidate these entities to enable them to carry out their responsibilities efficiently and to facilitate the development and implementation of a cohesive national educational policy. The United Kingdom, for example, has realized great efficiencies, reduced duplication of effort, and improved cooperation by combining education and labor in one department.

In addition, the federal government should periodically evaluate existing education and training programs for value-added benefits and discontinue or change the programs as appropriate.

The federal government should develop incentives for partnerships among business leaders, state and local government officials, educators, professional organizations, and other key groups.

Publication of the information resulting from federal data collection, research, and benchmarking (domestic and international) acts as a catalyst for innovation. The federal government should establish a national repository of information about education and make it available to the public. Particularly important is the dissemination of information about schools that have been pioneers in technology as a way of facilitating the replication of the best practices.

Schools in the 21st century must use technology as an integral component of educational reform strategies. Educators, insulated from the business world, have had little motivation to bring technology into the schools. Governments at all levels must provide the tools for and instruction in information technology that schools will need in the next century.

State legislatures and local school districts must take the lead in educational reform. States must empower local school officials by removing all obstacles to reform at the district and school levels, adopt

national educational standards, increase funding to ensure the implementation of reform measures, and encourage innovation, creativity, and school choice. Partnerships among state governors, business leaders, educators, and parents should increase, and biennial education summits should monitor the progress of reform and ensure the continuing commitment of all parties.

CONCLUSIONS

Our study of the U.S. education system raised many questions. The concept of the three pillars of education as a guide highlighted the linkage between the supplier (the school), the consumer (business), and the product (the student). The study confirmed that education is a vital U.S. industry and the cornerstone of our national power. Consequently, it must be nurtured, managed, and properly supplied with the resources it needs to ensure the continued world economic and political leadership of the United States.

The nation's power rests squarely upon the strength and vitality of its economy, which is driven by a well-trained and educated work force. Governments at all levels, but especially the federal government, must provide vision, direction, and, most important, leadership in educational reform. Additionally, U.S. students must be educated to and measured against world-class standards of achievement. One way to do so is to bring available technologies into the classroom and prepare teachers to fully exploit them.

The United States must empower teachers and principals to pursue innovative teaching methods and practices and break away from the traditional, rigid procedures that technology and time have outpaced. Alternative models of education are working well in isolated pockets around the nation; all educators need the opportunity to be creative and more effective.

Corporate America is becoming more involved in education and training reform and has created numerous progressive programs aimed at lifelong learning. The United States must continue to encourage business-school partnerships, explore other innovative methods that will prepare students

for the demanding world job market, and adapt overseas competitors' excellent examples of alternative schooling to the U.S. system.

In our view, education, the primary building block of U.S. economic, political, and military strength, must receive at least the same national priority attention as other social and economic issues do. Now that the public is finally beginning to focus on the problems facing the education system, the federal government must keep the momentum alive and the debate centered on the need for reform.

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ELECTRONICS INDUSTRY STUDY REPORT 1996

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ABSTRACT

The state of the U.S. electronics industry in 1996 shows significant optimism in contrast with the 1980s and early 1990s, when concern over the threat of unfair foreign competition, especially from Japan, alarmed the industry. There is a renewed confidence throughout many sectors of the industry. Computer sales in 1995 were strong compared with 1994. In the semiconductor sector, where competition from Japan was particularly felt, U.S. companies have surged back at the cost of their Japanese and European competition. The consumer electronics sector is showing a very healthy rate of growth. The U.S. continues to dominate the global software industry. The U.S. defense sector is an ever smaller portion of output. Consolidation leaves the firms remaining in the defense sector in a strong position, but concerns exist over national security implications of sole source suppliers and diminishing sources for dated equipment.

INTRODUCTION

The objectives of our study were, first, to develop a strategic perspective of the electronics industry and its role in supporting the materiel requirements of national defense in normal and emergency conditions; second, to conduct a comparative analysis of U.S. and foreign electronics companies in both defense and nondefense environments; and, third, to prepare specific policy options that would enhance the electronics industry's preparedness. This report centers on five elements: (1) the overall performance of the industry, (2) the structure and conduct of the industry, (3) the strategies of the industry, (4) the government's response to and enabling policies for the industry, and (5) a forecast based on an analysis of current trends.

The study was organized around a series of classroom lectures, seminars, and visits to U.S. and foreign electronics companies, including prime and subcontractor corporate headquarters, production facilities, and government and commercial research facilities. At the Electronics Industry Association, we received a comprehensive overview of the U.S. electronics industry, its standing, and the outlook for the future. During the domestic visits, we observed managerial processes at work in operational settings. Additionally, the foreign visits allowed us to

realistically assess the long-term ability of U.S. electronics companies to compete in the world market.

THE ELECTRONICS INDUSTRY DEFINED

The electronics industry is vibrant, global, vital to national security, and the dominant industry in the world today. Electronic products affect almost every aspect of people's daily lives from the electric clock radio that wakes people in the morning, to the electronic engine modules that run automobiles, to the microprocessor-controlled microwave oven that cooks people's food, and to the television set that brings the public news and entertainment--the U.S. economy, and U.S. national security. Electronics not only forms the nervous system of worldwide banking systems and medical technologies but is also the key element of nearly all defense weapons systems.

Structure

The U.S. electronics industry employs more than 2.3 million workers more than the automobile, steel, and aerospace industries combined. The Department of Defense (DoD) has become a nominal player in the industry. For example, in the crucial semiconductor market, DoD purchases currently represent only about 1 percent of total sales. The diminishing role of DoD is causing many firms to eliminate defense business and focus on commercial alternatives or to bail out of the industry altogether.

The electronics industry is extremely global in nature. Firms in all segments are spreading out geographically and establishing facilities and fabrication facilities (FABs) in foreign countries. Clusters of facilities and activities are growing in the emerging markets of the four Tigers (South Korea, Malaysia, Taiwan, and Singapore), China, and other countries in the Pacific Rim. Consequently, U.S. electronics firms often use foreign suppliers and sell to foreign producers or buyers.

The electronics industry is highly segmented, as evidenced by the six basic types of manufacturing and production firms: silicon wafer manufacturers, semiconductor manufacturers, computer manufacturers, consumer electronics manufacturers, material suppliers and producers,

and software producers. U.S. firms dominate the world market in the semiconductor, computer, and software segments. However, they play only a minor role in the consumer electronics manufacturing segment, which is dominated by Japan and Korea. At the base of the industry are the raw-material providers and the basic material producers. Many of the raw materials, including single-crystal silicon, are provided by foreign suppliers. For example, Hemlock Polysilicon, a U.S. silicon firm, buys most of its processed silicon from Canada, Brazil, and Sweden; only about 10 percent comes from the United States. MEMC Electronic Materials, Inc., a U.S. firm spawned by Monsanto and now the second-largest world supplier with a 20 percent market share, relies on its majority German owner, Huls AG, for polysilicon feedstock. Its strategic relationships with Germany, Korea, and Taiwan effectively guarantee uninterrupted supplies of critical raw materials.

The industry has a mix of single-segment and multiple-segment firms. For example, Micron Technologies produces semiconductors and supplies them to many other computer manufacturers. By contrast, IBM manufactures silicon wafers and chips and uses them in its own computer manufacturing. This vertical integration is becoming more prevalent in response to increasing production costs.

Cost and technological know-how are both significant entry barriers, especially in the wafer and semiconductor segments; however, cost is not a barrier for entry into the software industry. The high cost of manufacturing equipment and FABs prevent small firms from competing with larger ones. Additionally, firms must maintain their technical know-how to remain on the cutting edge.

Conduct

The near-unanimous position of the industry seems to be that the government should foster a business-friendly environment for a strong open market but should not otherwise get involved in regulating or directing the industry. The government, however, has been involved in many ways that have generally been regarded as positive for the industry. For example, in 1987 the government, industry, and academia formed SEMATECH, a partnership designed to revive the U.S. semiconductor

business. Another positive action is the U.S.-Japanese trade agreement, which caused Japan to open its markets to foreign semiconductors. Recent reports indicate that, as a direct result, foreign firms now claim over 29 percent of the Japanese market.

Government-supported research and development (R&D) is declining. The electronics industry has historically invested greatly in R&D and capital equipment, but recent industry studies indicate that, because of the exorbitant costs of capital and production equipment, surviving firms now invest less in R&D while weaker firms have either merged with stronger ones or collapsed. U.S. electronics firms are investing, on average, about 6-8 percent of annual sales in R&D about one-half to one-third the rate of R&D investment by their European and Asian competitors.

CURRENT CONDITIONS

The electronics industry constitutes approximately 14 percent of the nation's gross domestic product. More important, the capability to design and manufacture high-end and leading-edge technological products is a key element of the United States' national power.

The electronics industry has experienced an rate of growth that is unprecedented in the history of the modern world has. The American Electronics Association (AEA) estimates that domestic sales of U.S. electronics companies increased from $127 billion to $306 billion from 1980 to 1990 (Environmental Protection Agency, 1996, 10). In 1993, the United States accounted for 35 percent of the world's electronics output ("Electronics: Big, Bigger, Biggest," 1994, 41), and during 1994 the electronics/computer industry grew 13 percent (AEA, 1996, 1). Figures for 1995 indicate that U.S.-based factories produced almost $500 billion worth of electronics products, representing a 20 percent increase over 1995 (AEA, 1996, 1). By comparison, that same year the United States produced $54 billion in finished steel, $133 billion in automobiles, and approximately $133 billion in textiles. There are no indications that this upward trend will reverse itself in the near future.

The worldwide consumption of electronic products has grown significantly with respect to other goods. If 1996 estimates hold true, the electronics industry will have grown nearly 65 percent since 1990. As for

individual companies, revenues for Motorola and Compaq went from $5 billion and $500 million, respectively, in 1985 to over $22 billion and over $10 billion, respectively, in 1995 ("A Decade-Long Tech Boom," 1995, 10). The Integrated Circuit Engineering Corporation, a market research firm, projects that worldwide sales of electronic equipment will increase to $1.1 trillion by 1999 (Standard and Poor, 1995, E-16).

Semiconductors

The semiconductor is the nucleus of the electronics industry. The demand for semiconductors increased significantly during the early 1990s, especially in the computer and the telecommunications sectors. Advances in semiconductor technology contribute directly to second- and third-order growth effects within this and other segments of the electronics industry.

Worldwide semiconductor sales for 1994 exceeded $144 billion. North American sales grew 32 percent from 1993 to 1994, and the North American world market share of the semiconductor sector was 41 percent in 1994, followed closely by Japan with 40 percent (Standard and Poor, 1996, E-15). Semiconductor sales formed an increasing share of total electronic equipment sales and are expected to exceed 20 percent of the entire market by 1999 (Standard and Poor, E-27).

The major players in the U.S. semiconductor manufacturing business are firms that produce chips for their own consumption, such as IBM and Hewlett Packard, which have recently increased their investments in semiconductor FABs. Since the investment required to establish a semiconductor FAB is approximately $1 billion, only large companies can afford to do so. Although there is an apparent lack of U.S. companies among the top 10 semiconductor manufacturers worldwide, Intel, Motorola, and Texas Instruments (TI) (first, fourth, and sixth, respectively in the world) control over 50 percent of the global market.

The U.S. semiconductor industry today is far healthier than it was in the 1980s. In 1986 the Japanese merchant semiconductor companies captured 46 percent of the world market compared with U.S. companies' 43 percent. In addition, the U.S. commercial semiconductor industry is structurally different than it was in the 1970s and early 1980s. U.S. chip makers have steadily penetrated the Japanese market since 1986, when the

U.S. share of that market was only 8.6 percent. By March 1993, Japan was importing just over 20 percent of its semiconductor needs. The fundamental, sustaining difference is the development of global strategic partnerships and global alliances, which are supplementing the United States' rugged individualism in the worldwide marketplace.

While the Semiconductor Trade Agreement of 1986 and the SEMATECH government-industry consortium provided much of the impetus for this upward turn in semiconductor market access, the dense web of technology and production alliances was the key to shifting the trade balance. The North American Free Trade Agreement eliminated U.S. tariffs on 89 percent of Mexican electronics imports and Mexican import tariffs on 49 percent of U.S. electronics exports to Mexico. Mexico and Canada, the top two importers of electronics equipment manufactured in the United States, together import over 40 percent of the $7 billion annual exports of U.S. electronics equipment. The elimination of the tariffs is expected to cause overall sales to these countries to increase over the next several years.

Computers

Computer sales for the first three quarters of 1995 reached $50.7 billion, an increase of 16.4 percent over the same period in 1994 (EIA, November 16, 1995, web site: http://www. eia.org, 1.). This growth rate is typical of that experienced throughout the 1990s. Since mid-1994, when President Clinton lifted export restrictions on the sale of commercial computer and telecommunications equipment to Russia, Eastern Europe, and China, U.S. electronics firms have had access to billions of dollars of additional business opportunities per year.

The recently enacted Telecommunications Reform Act should increase domestic competition by driving prices down and increasing information services to private homes and businesses. Easier and cheaper access to the information highway, the growth of the Internet, advances in electronic commerce, and the general lowering of computer equipment prices will all significantly strengthen the computer market.

The technological advances that had a profound impact on the computer industry also affected the communications sector. Digital communications,

made possible by advances in semiconductor technology, are now affordable, creating another lucrative and expanding sector of the electronics industry whose overall market share is unaffected by DoD requirements.

The average dollar amount invested in R&D by the top 10 computer companies is just below 6 percent of their annual sales. The companies that lead R&D investment are Tandem Computers, with 12.77 percent of sales, and Silicon Graphics, with 11.96 percent of sales. These same two companies are ranked 11th and 13th, respectively, in total revenues in 1994 (Moody's Investor's Service, 1995, 43).

Consumer Electronics

The U.S. consumer electronics market grew 11 percent in 1995, posting a record $62 billion in sales. This sector continues to demonstrate strong growth each year, and sales are expected to exceed $80 billion by 1998 (Consumer Electronics Manufacturing Association, 1996, 7). In times of emergency, realignment of national priorities could make the remaining state-of-the-art consumer electronics manufacturing capability available to the defense industry.

Software

A recent industry survey states that the U.S. "makes an estimated three-quarters of the packaged software sold world wide. Approximately two million software programmers work in the U.S. -- twice the number in Japan, the next largest employer." As the report continues "software simply follows hardware," and "nearly half the world's computing power" is in the U.S. (The Economist, "Software Industry Survey," May 25, 1996, p. 14) Our international investigations revealed no current, credible challenge to U.S. supremacy in this area. Piracy and safeguarding of intellectual property rights are the most serious threats to the profitability and growth potential of U.S. software development and marketing firms.

DoD Implications

Two electronics products will have a major impact on national security: precision-guided munitions and the flat-panel display (FPD). The demand

for "smart weapons" will continue to increase even though their cost may become prohibitive. In a 1996 address to the Industrial College of the Armed Forces, a senior government leader said that the world is "a much more dangerous and unpredictable place than we imagine." Improved smart weapons will allow for "one shot, one kill," thereby putting fewer friendly forces and civilians at risk.

The FPD initiative has far-reaching implications for the U.S. military as an integral part of embedded weapon systems. Japan, the world's dominant supplier of FPDs and leader in FPD technology, has stated that it will not directly supply technology or products to the U.S. military. The U.S. invented the technology, but domestic industry failed to recognize its potential, feared competition with other products, and did not want to risk the start-up capital. The U.S. government recently cofunded manufacturing testbeds for FPD by rewarding R&D with support for follow-on technology product development to selected firms that commit to high-volume production facilities.

Pacing Item

Feature size (the submicron physical dimensions of integrated circuit components) and, therefore, chip density and performance are the pacing items of the industry. Dynamic random access memory (D-RAM) is the most obvious example, as decreasing feature size has made possible increases in per-chip memory capacity from less than 1 megabit to over 64 megabits today. In the near future, production of 256-megabit memory chips is slated to begin. There is currently a worldwide excess of D-RAM manufacturing capacity, primarily because firms in the Pacific Rim have built more chip fabrication plants in response to the shortage of a few years ago. In contrast, there is a capacity shortage for logic circuit chips - smart chips capable of computing, comparing, sensing, and converting; however, increased production capability is now coming on line worldwide. This shortage is indicative of the investment-profit cycle for the electronics industry as a whole: the industry goes through a six-year cycle of major investment, capital acquisition, and profit making on investment, so for significant periods of time any given segment of the industry might be at low capacity.

Industrial Strategies

Corporate strategies within the electronics industry fall into five major areas: product, organization, process and production, marketing, and human resources.

Product strategies. Firms such as Sony follow a broad differentiation strategy, characterized by leading in technology, being the first to market, using premium pricing, investing in new product R&D, and patenting (Porter, 1990). Sony supplies a broad array of products, whereas firms such as Intel use a focused differentiation strategy, concentrating on only a few products, such as microprocessors.

Many personal computer firms follow a cost focus strategy, which is characterized by technology "followership," manufacturing process R&D, and the purchase of licensing agreements. Such firms provide only a few products at minimum cost. In contrast, most defense electronics firms are attempting to shift to a cost leadership strategy, providing a broad array of products at the lowest cost.

The electronics industry is perhaps the only industry in which increasing quality can actually reduce costs. It is possible for a firm, particularly one that produces semiconductors, to follow a differentiation strategy, focus on quality, and end up with the least expensive product.

Organizational strategies. Many companies focusing on U.S. markets also find it necessary to move into the international market. When competing internationally, many companies have discovered that strategic alliances have numerous benefits, such as access to markets and new technology, economies of scale, assistance in making their product the de facto standard, and shared risk on innovative technologies. Strategic alliances may also reduce the need for capital. For example, TI has split the costs of a $1.2 billion fabrication facility in Avezzano, Italy, with the Italian government, and the IBM, Siemens, and Toshiba partnership formed to create the processes and technology for a 256-megabit memory chip allows for the pooling of innovative technology and the sharing of the risk involved in such a large project.

Another organizational strategy is to develop partnerships with suppliers. Stronger, long-term relationships allow suppliers to better understand a company's requirements, to anticipate needs, and to recognize that system engineering support and problem correction lead to reliable, long-term business. In a similar fashion, electronics companies are involving their customers in the development cycle of both products and chips much earlier as well as using integrated product teams to reduce the time it takes to develop products.

Process control and production strategy. The electronics industry is adopting process control and production strategies, which increase output by as much as 15 percent by decreasing the number of steps and processes required in manufacturing. These improvements include focused factories, integrated product teams, customer and supplier partnerships, just-in-time inventories, and continuous improvement methodologies.

The most significant systemic issue in the relationship between industrial capability and military mobilization is the existence of dual standards for contract administration and management, R&D, and production. Because of unique government requirements in contracting, not any real differences between the technologies used, defense contractors must often maintain separate means of contracting suppliers, training and certifying welders, selecting components, and setting up assembly lines for their consumer and defense lines. This segregation results in decreased productivity, wasted capacity, and a substantial cost premium to the government – typically tripling the administrative labor cost (van Opel, 1993, 14-15).

Marketing strategies. The core competencies of the electronics industry include a flexible response to market demands and decreased time to market. The industry worldwide recognizes that 70 percent of a new technology's profit potential goes to the "First Movers" firms that bring a new product to market first. Therefore, to the extent that material availability, process technology, mass customization, and systemic factors allow, the electronics industry is practiced in and capable of timely response. Such characteristics are vital to survival in the rapidly evolving environment of electronic technology innovation.

Human resources strategy. To maximize resources, many companies have entered into partnerships with local high schools, universities, and

governments at all levels. For example, over 100 companies have created partnerships and exchange programs with the University of Central Florida, the Naval Air Warfare Training Center, and Disney World in Orlando, Florida, to foster educational, research, and employment opportunities in computer modeling and simulation. In Austin, Texas, high-technology semiconductor manufacturers and personal computer system integrators have coordinated with the city and its high schools to prescribe a course of instruction for interested students in exchange for summer jobs and eventual full-time employment. Additionally, these firms have mandatory, in-house, continuing education programs to ensure that their workers remain technologically competitive.

CHALLENGES

Even though this study argues that the U.S. electronics industry faces a very promising future with a prolonged potential for significant growth, challenges do exist, including the following:

1. *Trade Issues:* The U.S. needs to continue to seek open and fair treatment of exports in electronics in certain markets. Although much attention still falls on Japan, growing problems exist with China, where U.S. exporters are unsure of regulations, including tariffs, that affect the movement of products through China's interior. Also, the U.S. will have to continue to seek adequate protection of its intellectual property, whether it is for the copyright on software or on "pirated" recordings and videos that are made in China and other locales. Within the U.S., protectionist concerns may not be as strong as in previous years, but the U.S. will need to continue to avoid unnecessary restrictions that would raise prices for consumers and, within the realm of national security, make it harder or costlier for the U.S. to acquire the best available technologies.

2. *Cost of capital:* Capital costs remain very high for certain sectors of the industry, such as semiconductors, in both research and development and manufacturing. This factor will continue to move companies towards the creation of co-operative agreements or alliances that help them share capital costs as well as expertise and manufacturing technologies. Although governments understandably need to monitor these agreements, they should be cautious when deciding to intervene to modify or halt an agreement. So far, the U.S. government has been very judicious,

regardless of whether of not the partners were U.S. or foreign owned. Simultaneously, U.S. companies appear to have reduced funds committed to R&D. If this proves to be a long trend, it could adversely affect the competitive quality of both the manufacturing technology and products themselves. Thus, the U.S. government continues to face the need to encourage a favorable climate for investment in R&D, whether through tax incentives or matching funding for select programs.

3. *Availability of key components:* With the growing importance of the commercial sector to the electronics industry, there is a danger that defense and military customers will be at the back of the line in corporate market strategies. For example, in semiconductors the commercial sector has almost completely ended its reliance on bipolar design, which is still used by some U.S. military customers. Additionally, the commercial world has little need for radiation hardening of its chips - a significant military requirement. These examples illustrate a larger question: in a commercially driven industry can the military be certain that it will be able to obtain key older-generation or specialized components that are used because they better serve military requirements, are uneconomical to replace because of large numbers installed in effective equipment, or are in place because of long procurement cycles that, heretofore, has been unable to keep up with the rapid generational changes in electronics technology.

OUTLOOK

Four major themes characterize the electronics industry in the United States:

1. U.S. electronics firms are major competitors in the world electronics market.

2. Electronics is a dominant and growing international industry.

3. Commercial electronics has outdistanced defense electronics, thus altering the market mix.

4. Current trends foretell a healthy and continually growing electronics industry through 2020.

Success on the battlefield of the future will depend on the availability of information. Modern warfare's command and control, intelligence, communications, logistics, and weapons systems will rely increasingly on electronics to provide the means to gain an information advantage over competitors. Some niche markets will have a relatively constant demand for highly reliable, high-technology military electronics. The challenge for defense planners through the year 2020 is to leverage commercial-sector development for military use. As a world power, the United States must take the lead in the technological and economic revolution. In the words of Winston Churchill, "It is no use saying, 'We are doing our best.' You have got to succeed in doing what is necessary."

With defense electronics sales representing less than 10 percent of the industry's total dollar volume, it is clear that defense requirements will not drive the marketplace. At the same time, commercial developments will aid defense program managers in many aspects of developing future generations of equipment for national defense. Among the developments most likely to be of value to defense planners are microengineering, convergence, digital signal processing (DSP), encryption, and wireless communication.

Microengineering

The recently developed ultra-small, three-dimensional silicon chip has a wide variety of military uses, including the creation of antennas, sensors, and other structures that do not exist today as solid-state devices. This technology will significantly enhance performance and reliability while reducing size, weight, and power requirements.

Convergence

The combined demands for reliability and capability will lead the shrinking of equipment and multiplication of functionality to continue. Within 10 years, military electronics will consist of multiple-use devices combining the functions of today's separate pieces of equipment. For example, a soldier might easily have a single device that combines the functions of a radio, television, sensor, computer, calculator, digital-imaging device, cryptographic equipment, fax machine, personal digital

assistant, global positioning system, mapping system, and electronic reference manuals.

Digital Signal Processing

This DSP family of integrated circuits/microprocessors is rapidly increasing the power and flexibility of all electronic items. Simply by reconfiguring the software, a programmer can use the same DSP microchip for an AM or FM radio, a guidance system for a cruise missile, a computer modem chip, an intelligence sensor, a cellular phone, or a video game. Because microprocessors are so cheap and powerful, it really does not matter economically whether 1 percent or 95 percent of a chip's capabilities are used in any given application. A practical example of DSP technology is the new family of tactical radios, known as SPEAKEASY, that is being designed for the U.S. military. Consisting of a chassis with a few simple controls and a selection of antenna inputs, the SPEAKEASY functions as an FM push-to-talk radio, a satellite transceiver, a high-frequency radio, or an aircraft transceiver. Command posts that previously required seven or eight radios can now use just one to communicate with a variety of units for less than a tenth of the former cost.

Encryption

The privacy of personal communications, the safeguarding of national and corporate secrets, and law enforcement intelligence are areas that lend themselves to encryption. Techniques for code breaking are now available to advanced amateurs, and outdated U.S. laws prevent U.S. companies from exporting technology that does not include a back door for getting into the product. Other countries not imposing such restrictions are starting to take over the marketplace. If U.S. policy on encryption does not change, the nation will lose its lead in advanced computer and network solutions.

Wireless Communications

The huge worldwide demand for wireless communications systems has had a profound effect on the technology of the electronics industry. For example, during 1995 Motorola built nearly 6 million cellular telephones,

more end items than they have built for the U.S. military in over 60 years of production. One can therefore see why firms pour R&D funds and corporate attention into the commercial market at the expense of the military even though the commercial market is the more demanding of the two. In addition to being rugged enough to stand up to field use by campers, hunters, and children, the equipment has to be easy to use, reliable, and affordable. By judiciously employing commercial equipment, the U.S. military can often buy better, faster, less expensive equipment for its own field use. It can also piggyback on the trend toward DSP to obtain multifunction radios at an affordable cost.

GOVERNMENT GOALS AND ROLE

The government's proper role is to provide a climate for free trade and to share the risk of future technologies that have a high cost and a high payoff. Historically, the U.S. government's attempts to help the domestic electronics industry have followed three paths: managed trade policy, managed industrial policy, and national technology policy.

Managed Trade Policy

Protectionist trade policies such as the 1986 U.S.-Japan Semiconductor Trade Agreement and antidumping actions concerning videocassette recorders have generally resulted in nominal help for selected industries while inadvertently damaging other U.S. consumers and industries that depend on the electronics industry. As mentioned, SEMATECH is a prime example of a government-managed industrial policy designed to maintain the U.S. industry's capability to manufacture semiconductor chips competitively. While there is controversy concerning the actual success of SEMATECH, history shows that within four years of its founding the United States reversed an indisputable decline and now commands a worldwide share advantage over the Japanese semiconductor industry. Another example is the FPD initiative, an ongoing industrial policy effort that is also a national security issue.

Managed Industrial Policy

The DOD's Technology Reinvestment Program and the Department of Commerce's Advanced Technology Program are attempts at developing technical policies. Both are cost-sharing, industry-led programs supporting dual-use technology, manufacturing processes, and enabling technologies, and Congress views both suspiciously as corporate welfare. Their continued existence is in question due to recent budget cuts (White House, 1995, 1-3).

A framework for a national innovation strategy proposed by the Organization for Economic Cooperation and Development (OECD) (de la Mothe and Dufour, 1995, 224) provides a structure for assigning general responsibilities and focusing the government's efforts. Briefly, in the OECD model the government provides a fertile environment, creates incentives for conduct where necessary, and builds and maintains infrastructure. Below we recommend U.S. government actions in each area.

Provide a fertile environment. The government should phase out protectionist strategies such as "Buy America" and tariffs except in the most predatory, egregious cases. These unilateral policies invite retaliation, often further injuring the very industries the federal government is trying to promote, and generally spill over into other foreign policy areas to cause more harm than good. Protectionist barriers should be relaxed rationally and bilaterally, and the United States must insist on reciprocity with each country and for each barrier dismantled. Should certain barriers need to remain, their application must be rooted in a simple, clear policy of supporting U.S. jobs and local production facilities regardless of actual company ownership. As a final lever, local firms are subject to Defense Procurement Act provisions in time of emergency. Conversely, the United States must resist the temptation to assist or meddle in foreign subsidiaries of U.S.-owned companies whose support, by virtue of their location, is not as reliable as that of domestic facilities.

Additionally, the government should create incentives for capital formation and thereby lower borrowing costs to enable U.S. electronics industries (with their high financial barriers to entry) to expand and

improve the U.S. domestic production base. Through a combination of commercial investment tax credits, policies encouraging personal saving and long-term investments, and targeted federal loan guarantees, the government can enhance the availability of this vital patient capital.

Government acquisition policies must be less adversarial and embrace a shorter cycle time and more efficient procedures to leverage off commercial capabilities. Steps to facilitate a stable, adaptive environment should include adopting a rolling, multiyear budget; eliminating separate R&D and procurement accounts, which unnecessarily inhibit flexibility and agility; using clear, unambiguous performance objectives; and clearly defining the warfighters' needs vice desires.

Create incentives for conduct as necessary. The government should continue to create incentives for R&D investment, such as the Advanced Technology Program and Technology Reinvestment Program models, but only in areas that are truly important to U.S. military or economic security. If U.S. industry fails to produce and sell competitively in the world marketplace, it cannot raise the capital necessary to keep innovating. The incentives must be as far upstream technologically as possible to yield the widest diffusion of benefits and must be funded cooperatively to ensure that the industry is a stakeholder in success.

In a more narrowly focused vein, industrial policy that targets sectors critical to national security should be used judiciously as a surgical tool of last resort. The Office of Science and Technology Policy (OSTP) must carefully and apolitically identify those industrial capabilities whose condition poses an unacceptable risk to national power. If the OSTP cannot accomplish this, we suggest an independent, appointed board of composition and charter similar to those of the Federal Reserve Board. The trigger for action under this policy should not be solely domestic availability. In determining whether access to needed technologies or components is sufficient, the board should consider multiple suppliers in multiple independent (not dogmatically aligned) countries an acceptable alternative. At the time of its founding, SEMATECH reflected an acceptable targeting under this policy. Today the FPD initiative is a good candidate given increasing commercial and military demand for this product, limited overseas suppliers, and the stated reluctance on the part of the largest world supplier to directly supply the U.S. military (Flamm,

1994, 1-24). Conversely, government support of the high-definition television initiative appears inappropriately focused on commercialization instead of further upstream on basic, enabling technologies.

Build and maintain infrastructure. Educated workers and a robust national information infrastructure (NII) underpin a competitive U.S. electronics industry. Because the industry's most important assets, its workers, walk out the door each evening at quitting time, saving existing jobs may not be the right goal. Making workers employable and productive through education is more beneficial in the long term than making death-delaying, normally futile attempts to oppose free-market forces. The role of today's high-technology workers is one of actively collaborating, understanding the entire production process, and using this perspective to fine-tune the process and increase productivity (Dertouzos, Lester, and Solow, 1989, 137).

To be successful, worker education must be a continuous process that is recognized as a vital capital investment for the future. The government should encourage work force training on the interrelationships among vendors, producers, and customers and the ways that the health and business strategies of each of the "food chain" members affect each other, overall productivity, and overall competitiveness. Additionally, the government should cooperatively fund efforts to improve the educational process, with an emphasis on just-in-time and on-the-job training. Workers who are able to immediately use newly acquired knowledge and can see its relevance to their own and their organization's performance are significantly more productive (Gansler, 1995, 203). Sharing costs with industry is important to ensure that corporate stakeholders remain interested in success.

National Technology Policy

Finally, the government must facilitate completion of the NII: today's counterpart to the interstate highway system. Its reliable operation is as crucial to defense and commerce in today's information intensive world as was President Dwight D. Eisenhower's road-building strategy in the 1950s. While the NII has evolved very well on its own, the government can make an immediate, effective contribution in the only area of particular vulnerability, transaction security. Unfortunately, efforts to do

so have been stymied by concerns about "big brother" eavesdropping. We believe that a secure NII is more essential to the public good than the law enforcement concerns others have raised. Accordingly, we propose to immediately secure selected "high-value" information such as financial, electric power dispatch, air traffic control, and defense-related transactions without mandating access to these transactions by law enforcement. Government standards and solutions are appropriate when interoperability and robustness are key. Other areas, particularly those involving high-technology intellectual property rights, should be allowed to implement their own schemes. Government technical assistance would be made available if requested.

The DOD's Opportunity

Because no serious national security threat exists today, the environment in the electronics industry is conducive to experimentation and prudent risk taking. In short, the DoD has an opportunity to find ways to accomplish its responsibilities better, quicker, and at an affordable cost. The DoD must use the fruits of the marketplace, judiciously repackage commercial components as environmental use dictates, and resist the urge to modify standards or commercial components, as uniqueness and incompatibility are dangerous bedfellows for military readiness. Additionally, the DoD must alter its reputation of being a difficult client, or soon its only bidders will be those who could not get work elsewhere. In so doing, the DoD will be able to provide state-of-the-art force multipliers to warfighters expeditiously and affordably in the years ahead.

CONCLUSIONS

The government alone can not enhance U.S. productivity and competitiveness, but it can foster a nurturing environment in which domestic innovative prowess can flourish to the economic benefit of the nation. Some areas may not have enough domestic manufacturing capability or redundant offshore suppliers to meet national security requirements, and prudent risk management may require some judicious corrective actions for the near term. However, "bull in the china shop" tactics are not needed in the electronics industry. Rather than being reactionary, government actions should be cautious and incremental except in the area of information security.

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ENERGY INDUSTRY STUDY REPORT 1996

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ABSTRACT

The working group recommended the following policies and measures for the U.S. government: (1) provide incentives to lower petroleum consumption in order to reduce environmental degradation and lessen the vulnerability of the economy to oil price increases; (2) delegate authority to draw upon the Strategic Petroleum Reserve (SPR) to a level below that of the president; (3) develop a coherent long-range strategy for carrying out the deregulation of the electric power industry; and (4) set priorities for investment in advanced technology that will contribute the most to the overall aims of national energy policy.

INTRODUCTION

Secure access to clean, abundant, and inexpensive energy is a fundamental requirement for an expanding and competitive economy. In the past 20 years, U.S. energy consumption has risen by more than 25 percent. And although the economy is becoming less energy intensive, that is, the amount of energy used to produce a dollar's worth of gross domestic product (GDP) is declining, energy production and distribution costs still represent about 8 percent of U.S. GDP. Energy imports are a major component of the U.S. international balance of trade, accounting for 10 percent of total imports.

Given the relationship between affordable energy and economic growth, sound energy policy is clearly an essential element of a broad national security strategy. The purpose of our study was to explore the role of the government in improving the productivity of the energy industry in environmentally sound ways and contributing to long-term economic growth, thereby enhancing U.S. national power. Our report frequently refers to the administration's *Sustainable Energy Strategy*, the July 1995 National Energy Policy Plan pursuant to Section 801 of the Department of Energy Organization Act. Using that strategy as a starting point, we have recommended the changes that we feel best serve the overall aims of U.S. policy. The group's strategic aims were:

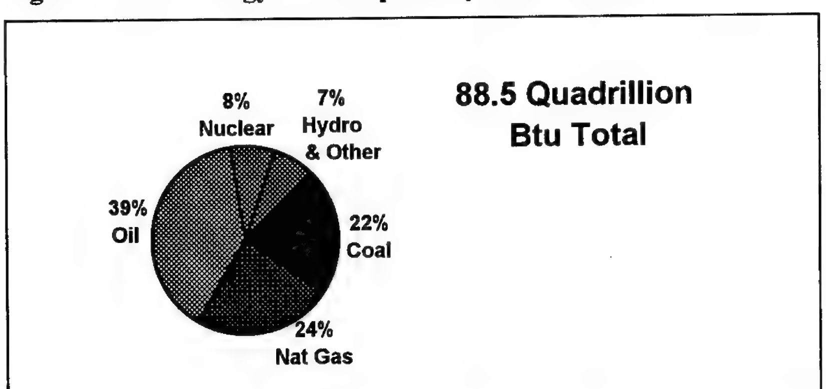
1. To sustain economic growth, improve industrial productivity, and improve living standards. Energy policy should encourage the development of secure and economical sources.

2. To protect the environment. Energy production always involves some environmental impact. Therefore, energy policy should promote better ways of meeting energy needs with fewer harmful effects on the environment.

3. To set appropriate priorities for the use of limited research and development (R&D) funds that establish a proper balance between basic and applied research. Energy policy should continue to advance the state of the art while ensuring adequate funding for research that is likely to produce clean, abundant, and affordable energy technologies within a reasonable time horizon.

4. To streamline regulations and make the government more efficient and responsive. When possible, energy policy should make use of market forces, rather than government regulation, to control undesirburden of needless regulation and administration.

Figure 1. U.S. Energy Consumption by Source, 1994



In the past 25 years, disruptions in oil supplies have caused price shocks severe enough to plunge the U.S. economy into recession on three occasions. Although most experts agree that oil price shocks such as those

that occurred in the 1970s and 1980s are less likely today, the United States depends more than ever on oil for its primary energy requirements (see Figure 1). The transportation sector accounts for 67 percent of the United States's annual oil consumption; cars and trucks alone account for half of the annual consumption. Therefore, any policy that seriously seeks to reduce oil consumption must somehow address the demand for gasoline and diesel fuel. Reducing petroleum consumption through increased efficiency or the use of environmentally friendlier substitutes would reduce environmental degradation.

The Strategic Petroleum Reserve (SPR) was not used as effectively as it could have been during the Gulf War crisis. Although a formal U.S. and international process was in place to respond to crises in world oil markets, those mechanisms became encumbered by the political process. In hindsight, it would have been better to remove the formal implementation process from the political arena.

Demand for electricity constitutes a little more than a third of the overall energy use in the United States. In the past two decades, electricity requirements have increased by about 3 percent per year, but this growth in demand has already slowed and is expected to slow even more by 2010, averaging slightly more than 1 percent per year (*Sustainable Energy Strategy*, 1995, 41). The current movement toward deregulation of the electric power industry is consistent with the long-range goal of keeping energy costs down, but a major problem with deregulation is the lack of a comprehensive government strategy for carrying out deregulation. At present, the administration has not announced how it intends to resolve the issue of stranded costs equitably. The uncertainty of the future regulatory environment caused by this leadership void has prompted the various utilities to delay recapitalization plans.

In recent years the Department of Energy (DOE) budget for both applied and basic research has been reduced. Those budget reductions have resulted in some de facto energy policies that should be reexamined. The average expected cost-benefit time horizon, which has grown too long in recent years, should be shortened.

THE PETROLEUM INDUSTRY

The Petroleum Industry Defined and Current Conditions

The United States consumes more than 25 percent of the world's oil production. The U.S. domestic oil industry is very mature, and production has been on the decline for years. Today, proven U.S. oil reserves represent only about 2 percent of world's total, which has led to increased overseas exploration. U.S. production will continue to decline until around 2005, when a slight increase is expected as a result of emerging three-dimensional seismic analysis and horizontal drilling technologies jointly developed by the DOE and the oil industry, and the increased development of deep-water offshore oil wells in the Gulf of Mexico. Another largely unexplored area is the Arctic National Wildlife Refuge in Alaska, but current federal law prohibits production in that area.

Challenges

The two overriding U.S. national security concerns associated with the petroleum industry are the vulnerability of the U.S. economy to oil price shocks and long-term price increases, and the environmental impact associated with fossil fuel energy sources. Because nearly 40 percent of the United States's primary energy is supplied by petroleum and because much of the world's oil is produced in the volatile Persian Gulf region, price stability is a major concern.

The central environmental issue concerns how extensive governmental environmental controls should be and how they should be implemented. The petroleum industry is subject to government regulation in the extraction, processing, transportation, and use of petroleum products. Clearly, in all these endeavors, environmental risks exist. The question becomes how to work more effectively with industry, create incentives for responsible behaviors, and protect the environment while promoting affordable and secure energy sources. A particularly contentious environmental issue is global climate change. Many, but not all, scientists believe that burning fossil fuels results in irreversible and detrimental climate changes. If that is indeed the case, then limitations on fossil fuel consumption--on a global level--must be agreed upon.

Outlook

U.S. petroleum production is declining while world oil consumption is rapidly rising. That increased demand will be supplied primarily by production from the Organization of Petroleum Exporting Countries (OPEC). Most of OPEC's production will come from the Persian Gulf region, where two-thirds of the world's oil reserves are found. While there will always be some non-OPEC countries with significant amounts of oil for export (e.g., the United Kingdom, Norway, Colombia, Vietnam, Yemen), OPEC's share of world oil production is expected to increase in the next 20 years.

Motor gasoline, distillates (which include diesel fuel and heating oil), jet fuel, and residual fuel (mainly used by industry as a boiler fuel) make up 80 percent of all refinery production in the United States. Of the petroleum products used in the United States, transportation fuels account for nearly two-thirds.

Domestic refinery production has steadily increased over the last dozen years while reserve refining capacity has declined. Passage of the Clean Air Act Amendments of 1990 forced the closure of a number of small and inefficient refineries that were no longer economically viable as a result of the associated compliance costs. While refining capacity has declined, refined product consumption has risen, substantially increasing the utilization rates of U.S. refineries. However, a significant secondary processing capacity brought on line in the last few years allows further processing into more valuable products, such as motor gasoline. Another result of recent environmental regulations is the substantial increase in the number of required refined products. U.S. refiners must produce different types of gasoline, from reformulated to oxygenated, depending on the season and the region of the country in which the gasoline is consumed. This requirement has tested the limits of the flexibility inherent in the U.S. refining industry.

Government Goals and Role

To reduce the sensitivity of the U.S. economy to oil price shocks and long-term price increases, to provide incentives for investment in advanced technology, and to reduce the environmental impacts associated with the burning of fossil fuels, we advocate the following measures.

In addition to the current fuel efficiency regulations, we recommend gradually increasing the federal gasoline tax by 25-50 cents over the next five years. Those tax increases should be offset by reductions in other taxes, such as the federal income tax base rate, thus minimizing the economic costs of implementation. The gasoline tax is a very efficient way to cost out the externality of vehicle air pollution. Ideally, the market leverage provided by the gas tax would result in a fleet of more efficient vehicles and a reduction in vehicle miles traveled; neither of those objectives is obtained through the use of fuel efficiency standards. Nonetheless, if an increase in the federal gasoline tax proves to be politically nonviable, then the mandated fuel efficiency requirements should be revised upward and a gas-guzzler tax should be considered.

The group supports the removal of all remaining tariffs and advocates an open and free international oil market. We do not recommend using unilateral oil embargoes as an economic weapon. Also, since the U.S. SPR is the nation's best strategic hedge against oil supply disruptions, we advocate maintaining its current levels. Recent decisions to sell part of the SPR are shortsighted. The group also concluded that the SPR was not used as effectively as it could have been during the Gulf War. To preserve the integrity of the decision-making process, that is, to ensure that domestic politics do not overcome the formal process of evaluating world oil markets in a time of crisis, the group recommends that the authority to access the SPR be delegated to a level below that of the president. Finally, the group recommends additional scientific research on global climate change in order to determine the appropriate role of the government relative to that concern.

THE ELECTRIC INDUSTRY

The Electric Industry Defined and Current Conditions

Industrial companies, not utilities, once supplied more than half of the United States' electricity. Over the past half century, however, the primary suppliers were regulated utilities exercising monopoly power. Buyers could not search out alternative suppliers, and potential alternative suppliers had no means of delivering their product. The electric utilities also enjoyed monopsony power in purchasing electricity from nonutility producers. Perceived as a natural monopoly dominated by large, vertically integrated companies, the industry became one of the most heavily regulated in the United States at both the federal and state levels. Other countries either followed suit or assumed direct control through parastatal companies.

The traditional structure of the industry is related to the formidable barriers to entry. Base-load power plants and transmission and distribution systems are expensive. Once a firm had laid down those systems for its service area, investment costs for competing networks were prohibitive. State public utility commissions used established cost-based pricing methods to fix rates, encouraging utilities to emphasize reliability and expansion of service over cost. Public commissions used the rate structure to cover social costs such as extending service to uneconomical areas and subsidizing renewable energy demonstration projects. On the whole, utilities have been reasonably profitable. Return on equity has been consistently above 11 percent and was over 12 percent in 1994.

Today, the industry is on the verge of a massive change: deregulation. Federal and state regulators, who may struggle among themselves to determine their own roles as well as what regulation may still be required, will watch over the emerging marketplace of utility winners and losers. As the industry faces deregulation, it finds itself with 21 percent overcapacity and slowing demands for electricity. During the 1960s, the ratio of electricity demand to GDP growth was nearly 2:1. This ratio fell to 1.5:1 in the 1970s and nearly 1:1 in the 1980s. The Energy Information Administration (EIA) projects that this ratio will fall to 0.5:1 during 1993-

2010, mainly as a result of improved energy efficiency (EIA, "Annual Energy Outlook 1996," January 1996, Tables A8 and A20.).

Challenges

Technology, economics, and political and social goals are interacting to force change on the electricity industry. The foundations for these changes are in the 1978 Public Utility Regulatory Policies Act (PURPA) and the Energy Policy Act of 1992 (EPACT). EPACT specifically eases rigid government controls, creating a new category of power producers, exempt wholesale generators (EWGs). Utilities can be required to provide EWGs with point-to-point access to transmission systems, thereby unbundling generation, transmission, and distribution functions. The logical extension of this deregulation trend is the Electricity Competition Act of 1996, now awaiting congressional action , which provides for retail wheeling--opening competition to buyers and sellers to make transactions over an open, nationwide power grid.

The strategic issues arising from deregulation are complicated. In the near term, the most fundamental questions for government policymakers are how much of the industry can be deregulated, whether deregulation includes transmission and distribution systems, what constitutes reasonable compensation for utilities' stranded costs in a deregulated market, and, as retail wheeling becomes a reality, whether utilities and their shareholders are entitled to compensation for major capital investments, such as nuclear power plants. These capital investments were frequently predicated on investment strategies mandated by local utility commissions and regulated but guaranteed rates of return. Likewise, the federal government required nuclear-powered utilities to contribute to developing the Yucca Mountain high-level nuclear waste storage facility in return for its completion not later than 1998, when 26 civilian nuclear sites will exhaust their on-site storage capacity. Yet 2010 is the DOE's current projected date for opening Yucca Mountain.

In the long term, as the industry focuses on the most efficient way to produce power in a competitive market, fuel sources must remain diverse enough for national security. The market must also manage the national power grid by providing for secondary services such as variable voltage

support, generation, and load matching and accounting for transmission losses, spinning reserves, and black startups.

Outlook

The electricity industry will be able to meet projected demand both in the short term (1-5 years) and long term (5-20 years). But the deregulated industry of the next 20 years is likely to be considerably turbulent. Real prices will come down, overseas investment will rise, and environmental concerns may suffer absent corrective measures.

Government Goals and Role

Experience with the deregulation of other industries and the early reaction of utilities to shed unnecessary costs confirms that open competition is more efficient than central planning in producing reliable, cost-efficient services. While the administration plans to assess the impact of deregulation before reforming PURPA, the working group felt that those reforms should be accelerated. In areas where open markets are unable to satisfy basic requirements, more flexible regulations should be adopted.

The electrical transmission and distribution system should remain a regulated monopoly to preclude many of the issues associated with stranded benefits and mitigate some of the problems associated with utility compensation and power-grid management. The role of the government in the future should be to monitor the performance of the new market, including watching the deregulated industry for anticompetitive behavior, such as "cream skimming," and tracking providers of generation and distribution in all regions to ensure the maintenance and management of the nation's power-grid system. As deregulation proceeds, the federal government should also ensure that former public utilities and their shareholders receive adequate compensation for their real stranded costs as a result of investment actions directed by local utility commissions. Finally, given the near-term nuclear waste storage and disposal problems and the increasing possibility of early retirement of some uneconomical nuclear power facilities, the federal government must immediately either open the Yucca Mountain high-level waste facility or find alternatives.

The federal government should develop a coherent long-range strategy for the deregulation of the electric power industry. Regulated monopolies are antithetical to market economies, are a drain on the private sector, and result in artificially high prices, weaker market incentives, restricted output, and less innovation. Competition, even imperfect competition, is preferable. Government policy must provide for careful monitoring of the deregulation of the industry and the maintenance of the nation's energy security.

THE COAL INDUSTRY

The Coal Industry Defined and Current Conditions

Coal continues to be one of the United States's most important energy sources, providing nearly 60 percent of the nation's electrical power. In addition, the coal industry directly contributes more than $21 billion to the economy each year, and its total contribution, through its impact on other business sectors such as the transportation industry, is over $132 billion annually. The coal industry employs about 136,000 people, directly affects another 1.4 million jobs, and contributes an estimated $4.5 billion annually to the positive side of U.S. balance-of-trade payments. Coal exports are growing and hold promise for the future. U.S. coal producers ship more than 80 million tons of their products per year to approximately 40 different countries, including the major markets of Japan, Canada, Italy, the Netherlands, and Belgium.

Coal is in plentiful supply within U.S. borders. Proven U.S. recoverable coal reserves are the greatest of any single nation and represent about 23 percent of the world total. At present rates of recovery and use, U.S. coal reserves are expected to last more than 250 years.

The coal industry has a broad base of suppliers. There were 59 major coal producers doing business in the U.S. at the beginning of 1994, 8 of which were controlled by foreign firms. Production concentration ratios are low relative to those of most other major industries, with the top four producers accounting for around 22 percent. The increased demand for low-sulfur coal caused by the Clean Air Act and the lower production costs inherent in large surface mines in the West have contributed to a

decline in the number of inefficient and high-sulfur producing coal mines in the industry (from 6,000 in 1980 to about 2,300 in 1994).

Since the 1970s, U.S. coal production has grown substantially, and the coal industry has significantly improved productivity. Current annual production is approximately 1 billion tons--an increase of 90 percent since 1970. Coal mine productivity has also risen sharply, more than doubling since 1980. This growth and improved efficiency is due mainly to the introduction of modern technology into virtually all phases of mining. The most visible effects of modern technology are a significantly reduced but highly efficient work force, resulting in a steady decline in coal prices. From 1982 to 1994, prices fell from $27 to $19 per ton. In addition to increased productivity, mines today are also much safer than in the past as a result of sophisticated mining and safety technology (roof-bolting techniques in particular), improved training techniques, and compliance with safety and health laws.

Challenges

The principal challenge to the coal industry in the 21st century will be coping with environmental concerns. The industry will need to find less expensive technologies to reduce acid rain emissions in order to comply with the Clean Air Act amendments, or it will face a continuing decline in its share of the deregulated electricity market. If new regulations regarding greenhouse gas emissions are enacted, all fossil fuels, including coal, will be affected.

Outlook

Today coal accounts for approximately 22 percent of the U.S. total energy consumption and is expected to hold that share through at least 2010. Estimates are that demand in the industrial market will rise by 0.6 percent per year through 2015. More exports are expected as developing economies expand and require more steam coal to generate electricity. Overall production is expected to rise to an estimated 1.24 billion tons in the year 2015 while the real price of coal declines by 0.3 percent annually over the same period. The number of coal mines is projected to decline further as the industry continues to consolidate into fewer, larger firms.

Government Goals and Role

In terms of U.S. strategic energy goals, coal's impact on water quality, clean air, and land reclamation presents environmental risks rather than economic or security concerns. Specifically, the U.S. government's goals concerning coal should be to prevent damage to ground and surface waters, to reduce harmful air pollutants, and to return mined land to a condition at least as good as the original. The Clean Air Act, the Clean Water Act, and the Surface Mining Control and Reclamation Act all reflect intensive government scrutiny and regulation of the coal industry. In concert with its role of helping develop technology to ensure clean and affordable energy, the government spent $2.58 billion on clean-coal technology demonstrations from 1988 to 1995. These demonstrations initially focused on emission control systems but in later years have focused on highly efficient, environmentally superior advanced power systems. Given the anticipated increased use of coal as an energy source in a deregulated electricity industry and the potential for early retirement of nuclear power facilities, developing more affordable clean-coal technology becomes increasingly important. Current government spending on clean-coal R&D does not reflect this trend. We believe this should be corrected.

THE NATURAL GAS INDUSTRY

The Natural Gas Industry Defined and Current Conditions

The current estimate of proven world gas reserves is nearly 5,000 trillion cubic feet (TCF), with approximately 40 percent of the known reserves located in the former Soviet Union (FSU). Eastern Europe, the FSU, and the Middle East account for approximately 70 percent of the total. Proven domestic natural gas reserves in 1994 were about 164,000 billion cubic feet (BCF), a decline from 197,000 BCF in 1984. Domestic reserves exist principally in five areas: Texas (22 percent), the Gulf of Mexico (17 percent), New Mexico (19 percent), Oklahoma (8 percent), and Wyoming (7 percent). Mature economies such as the United States, Canada, western European nations, and Japan are the principal natural gas consumers.

Developing nations often possess substantial natural gas reserves but lack the necessary infrastructure for distribution and consumption.

Domestic natural gas production in 1994 reached its highest level since 1981. Three-dimensional seismic analysis linked with computer-driven visualization, geochemical analysis, horizontal drilling, and other new technologies have greatly enhanced exploration efforts. Shell Oil is planning a Gulf of Mexico platform in an impressive 5,400 feet of water. Notwithstanding these efforts, the United States is a net importer of natural gas.

The Federal Energy Regulatory Commission (FERC) unbundled suppliers and pipeline companies with the issuance of Order 436 in 1985 and Order 636 in 1993. Increased competition for gas sales, an expanding resale market in the transportation sector, and new services have emerged as companies have entered new markets. Companies have sought to strengthen their positions through consolidations, diversification into unregulated energy markets, and strategic alliances to capitalize on opportunities not available to individual companies.

The domestic natural gas pipeline network is mature and efficient. Increased demand since 1990 has propelled a 14 percent increase in pipeline capacity largely due to development of new Canadian supplies and increased demand in Western and Northeastern markets. An anticipated increase in the use of natural gas in the electric power generation market is also driving new construction. Storage capacity in the United States, now is approximately 8,000 BCF distributed among 375 storage sites, has increased by 10 percent since 1990 as customers seek greater efficiency and supply reliability. The development of planned storage sites will increase capacity another 9 percent by 2000. Although natural gas can be transported by specially designed tankers when in a liquefied state (liquefied natural gas, LNG), the costs associated with LNG processing and transport have led to the selection of pipelines as the preferred means of natural gas transport in the U.S.

The natural gas consumption of utilities and nonutility power generators is rapidly increasing. Utilities favor natural gas as a cycling or peak power source, relying on other sources, such as coal or nuclear fission reactors,

for base-load power. The primary domestic use is for heating, so natural gas consumption is highly weather sensitive. The increased efficiency of home heating systems, however, has somewhat mitigated the growth in the demand for natural gas for heating and cooling.

Natural gas market prices have fallen over the last decade. Because gas prices exhibit great volatility, the futures market is used to manage price risk. Natural gas trading on the New York Mercantile Exchange is averaging over 36,000 contracts per day in 1996. By comparison, daily oil contracts are averaging around 102,000.

Challenges

The costs and environmental impacts of other electricity-producing fuels, such as coal and nuclear fission, have made natural gas the fuel of choice for future generating capacity. Gas is cleaner than coal, but most existing coal-fired plants are more economical to operate. The use of advanced technology shows promise in finding new reserves to replace depleted ones. For example, improved exploration and deep-water production technologies could aid in the discovery and development of offshore fields and reduce the cost of natural gas.

The government and the natural gas industry are exploring the use of natural gas as a substitute for gasoline in the automotive industry. Although some ventures have been successful, the shortage of distribution stations and the limited amount of natural gas a vehicle can carry are significant barriers to widespread market entry. If those barriers are overcome, it is likely that more government and individual users will convert to natural gas. The EIA projects an increase in the use of natural gas-fueled vehicles by 2010, primarily in government fleets.

New gas pipelines will have to be constructed to support the projected growth in demand for natural gas through 2000. Consumption is expected to increase to 22 TCF, with the major growth requirements focusing on electricity generation. Several of the companies we consulted predicted growth of around 35 percent by 2010. Although pipeline accidents are relatively few, initiatives by the Department of Transportation and

Congress have worked to ensure that this method of transportation remains safe.

Outlook

The drilling market is expected to grow at an average annual rate of 3.9 percent over the period 1993-2010. While technological advances can reduce the cost of production, high local distribution center costs will hurt the market. Energy use in the industrial sector is projected to increase by 18 percent by 2015, driven largely by distribution costs. The use of natural gas as a fuel for electricity production is expected to increase in the near term.

Government Goals and Role

In general, past legislation and policy initiatives have attempted to expand natural gas markets, while regulatory reform has focused on creating a more efficient and competitive market. Market reform has centered on restructuring interstate pipeline companies and their relationships with producers, local distribution companies, and end users. Of particular note, FERC Order 936 (1985) provided third-party access to pipelines, the Clean Air Act Amendments of 1990 set new air-quality standards, and FERC Order 636 "unbundled" pipeline services.

The DOE, which has the primary responsibility for managing the federal government's promotion of natural gas, received a natural gas budget appropriation for FY 1996 of $267.5 million, a 28 percent increase over the prior year. A Natural Gas Coordinating Committee was recently established to ensure a single strategic focus for all federal programs involving natural gas. Federal goals regarding natural gas are to (1) foster development of advanced technologies, (2) encourage its use in new and existing markets, (3) remove regulatory impediments to its use, and (4) maximize its environmental benefits.

The federal government assumes a number of roles to accomplish its stated goals. It will provide direct and indirect support to explore specific applications such as advanced gas turbine systems, fuel cells, natural gas vehicles, building applications, and cleaner industrial systems. Current

research programs involve three-dimensional seismology, horizontal drilling techniques, improved fracture detection, and less intrusive drilling methods. By the end of FY 1995, some 16,700 natural gas vehicles were in federal service, about 20 percent of the nationwide inventory. Furthermore, tax incentives have been established for state, local, and individual purchases of these vehicles. Federal research money has funded the development of new gas turbine and combined-cycle power systems to encourage the expanded use of natural gas for cycle and peak electricity generation.

Programs are now in place to promote the recovery of gas reserves in environmentally sensitive areas. Royalty rate reductions may encourage exploitation of marginal onshore wells, and current research is seeking a better understanding of atmospheric emissions and ways to reduce methane losses from producing wells.

THE RENEWABLE ENERGY SOURCE INDUSTRY

The Renewable Energy Source Industry Defined and Current Conditions

Renewable energy sources (other than hydroelectric power) constituted only 3.5 percent (3.2 quadrillion Btu) of the total energy consumption in the United States in 1994. Although the contribution is minor on a national basis, renewable energy sources have very significant local effects and potential. Just as the use of renewable sources is expected to grow annually at a rate of about 1.5 percent, energy demand is projected to rise at about the same rate. Accordingly, the share of primary energy contributed by renewable sources is not expected to change by 2015.

Challenges

Renewable energy sources provide both unique advantages and associated challenges. In general, although renewables are attractive sources of energy because they are relatively clean, all have significant barriers to market entry that make them unattractive from an economic standpoint. For example, wind and solar sources are intermittent, so it is virtually impossible to match availability to periods of demand. Compared to fossil

fuels, renewables are diffuse energy sources and require greater capital investment in equipment to "capture" the energy, often over considerable acreage. Frequently the investment in renewable technologies is up-front, making financing of projects nearly impossible absent government funding. The utilization potential of several sources (e.g., wind, geothermal, solar, and hydroelectric) is also very localized or geographic in nature.

Outlook

The growth potential for renewables varies regionally. For the most part, development has been in niches where particular local or regional conditions are economic. Renewable energy systems are typically small- to medium-scale projects tailored to meet specific local needs. The potential of some renewables and their supporting technology as export products is a noted advantage. In particular, photovoltaics are globally marketed where power grids are not established; off-grid usage in remote areas (e.g., vacation homes, highway emergency call boxes) has a domestic market as well. The key factor that has prevented more rapid expansion of renewable energy sources to meet the nation's energy needs is the cost of efficiently producing usable energy from them, which can be as high as 10 times the cost of production by traditional means. The low price of fossil fuels has limited the economic incentive for turning to alternative sources, particularly in light of the high up-front capital costs associated with manufacturing and plant construction.

CONCLUSIONS

Investment in Advanced Technology

The classic debate over the merits of applied versus basic research relates to the market value and time horizon factors associated with each. Applied research is generally more market oriented and directed toward near-term results, while basic research generally involves longer-term efforts that do not necessarily produce market-oriented products. In recent years the DOE budget for both has been reduced, but applied research has been cut much more than basic research. Of the applied research efforts that remain, many are still oriented toward very long-range goals. Also, the

pressures of competition resulting from deregulation and the need to protect the short-term interests of corporate investors have forced the energy industries to respond by rapidly downsizing, consolidating, and reducing R&D expenditures, and nearly all of the private investment in energy-related R&D that has been eliminated is in the applied research category. The question for the government is how best to balance the advancement of state-of-the-art technology with adequate investment to support the intermediate- and short-range strategic objectives of national energy policy.

After examining the DOE's investment priorities as they related to the attainment of the working group's stated strategic aims, we concluded that the government's investments in energy-related R&D over the past two decades have not been as effective as they might have been in reducing U.S. dependence on petroleum or providing affordable means of reducing the adverse environmental impact of energy production. The group concluded that the current energy research budget is too heavily weighted toward extremely long-range projects with questionable potential for large-scale and affordable implementation. For example, research on fusion energy, a technology whose commercial application is still decades in the future, consumes 15 percent of the energy R&D budget ($368 million in FY 1995). At the same time, funding for some extremely promising projects is currently inadequate. For example, only $1.6 million (less than one-tenth of 1 percent of the FY 1996 energy budget) was earmarked for research on reductions in transportation demand. And clean-coal technologies and nuclear fission are currently receiving only about 8 percent and 4 percent of the R&D budget, respectively. The final report of the Energy Secretary's in-depth study of R&D, completed in June of 1995, was notably short on specific recommendations for setting priorities for projects.

The working group concluded that a wholesale reexamination of the DOE's R&D budget priorities is in order. The average expected cost-benefit time horizon, which has grown too long in recent years, should be shortened. The DOE should evaluate the role of potentially high-return R&D efforts in such areas as clean-coal technology, standardized advanced light-water nuclear reactor designs, and transportation demand reduction. Potential candidates for reduction (because of extended cost-

benefit time horizons) would include segments of renewable energy (such as wind and solar thermal power), fusion energy, and basic energy sciences. In summary, the DOE should reformulate and set priorities in a comprehensive, synergistic R&D plan that balances the goals of applied and basic research by evaluating the cost-benefit time horizon of each.

Sound Energy Policy

The study group concluded that the United States requires secure access to clean, abundant, and affordable energy sources. The government should institute policies to achieve the following overall aims of sound energy policy: (1) to encourage and sustain economic growth, improve industrial productivity, and improve living standards; (2) to protect the environment; (3) to use limited financial resources wisely; and (4) to make the government more efficient and responsive.

After examining the Sustainable Energy Strategy, the group felt that additional measures were necessary in four areas. First, the current strategy does not adequately address the United States's increasing vulnerability to oil price increases and the damage to the environment caused by increasing petroleum consumption. Second, the strategy fails to identify a time-phased plan for the deregulation of the electric power industry. In addition, the strategy generously funds research projects that do not substantively contribute to the stated aims of the strategy and hence wastes limited resources. Finally, procedures for accessing the SPR during a time of crisis should be freed from the political process by a formal delegation of authority to a lower level.

Our policy recommendations do not offer a panacea, but the group concluded that they would serve the overall aims of sound national energy policy. Implementing the recommendations in this report will contribute to the nation's security and prosperity, which, in turn, will enable the United States to continue to execute its vital global leadership role.

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Sustainable Energy Strategy, The National Energy Policy Plan Pursuant

ENVIRONMENT INDUSTRY STUDY REPORT 1996

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In harmony with the Tao,
the sky is clear and spacious,
the earth is solid and full,
all creatures flourish together,
content with the way they are,
endlessly repeating themselves,
endlessly renewed.

When man interferes with the Tao,
the sky becomes filthy,
the earth becomes depleted,
the equilibrium crumbles,
creatures become extinct.

Lao-tzu, 500 BC

ABSTRACT

This report discusses the basis of environmental concern in the United States, explores the role of the government in dealing with environmental issues as they relate to industry, reviews the role of industry in relation to the environment, analyzes the impact of environmental issues on industry, and makes recommendations based on conclusions drawn from our study.

INTRODUCTION

Lao-tzu, the Chinese sage quoted above, wrote his words of wisdom in the *Tao Te Ching* about 2,500 years ago, but the words have come to resonate more intensely since his thoughts were first recorded. In the process of conquering the planet, humans have lost their sense of a proper balance with nature and now find themselves on the horns of a dilemma: How can they meet the needs of the present generation without compromising the opportunities of future generations? The answer is the concept of sustainable development.

Over the past 25 years people have begun to realize the consequences of their neglect and abuse of the earth and have acted to reverse the trends that eventually could irreversibly alter life on earth as people have come to know it. The basis of all concern for the environment is the quality of the land, air, and water and the availability of the natural resources needed for reasonable economic progress.

Just how serious is the environmental problem? Some say that the effort to bring about necessary changes has gone too far and that those changes will be detrimental to economic health. Others say that the effort to

reverse a pattern of development that will prove to be cataclysmic for all species, including the human species, has not gone far enough. Beyond the basic issues of ground, air, and water pollution, which are the principal focus of industry's concern about the environment, lie a host of related issues that require a response. Among these are global climate change resulting from the accumulation of greenhouse gases and depletion of the ozone layer, deforestation, desertification, depletion of resources, the availability of potable water, and the extinction of plant and animal species. Taken collectively, these issues are evidence of a noticeable pattern of neglect and abuse with potential long-term ramifications.

The environmental problem is real and is inexorably linked to economic development. Indeed no intelligent, fair, and acceptable approach to dealing with this problem can fail to consider the interdependencies among environmental problems and the issues associated with sustainable development for all nations. In the final analysis, sustainable development must serve as the basis for all sound environmental practices. An effective response must be a joint effort by the government and industry, both nationally and internationally.

THE ENVIRONMENTAL INDUSTRY DEFINED

Environmental considerations are integral to everything that all other industrial segments do in the course of their business. Part of the nation's industrial sector is specifically focused on environmental concerns, but environmental issues affect industry as a whole. Based on our research, site visits, and discussions with leaders from government and industry, we have formulated the following definition of the environmental industry.

The environmental industry is a multifaceted base of manufacturing and services that involves two segments of industry. The first consists of the purely environmental companies, which seek to ameliorate the effects of past abuses and develop new products and processes that are consistent with environmental concerns. These firms include those that develop and market environmental technologies to resolve process deficiencies and handle waste and support remediation functions for other industries. The other segment includes industries in general that have applied environmental technology to ensure their continued economic viability.

We had the opportunity to see both aspects of the industry; however, our primary focus was on industry in general as affected by environmental issues and government regulations.

Although environmental issues and their impact on industry are international concerns, our principal focus was the United States. Our international studies and visits served primarily as a basis for comparison and a source of new ideas. In this report we address international issues only from the perspectives that environmental problems do not recognize political boundaries and that industry is increasingly global, which requires approaches broader than those mandated by individual nations.

CURRENT CONDITIONS

Until the late 1960s, industry seemed to be unconcerned with the environment. Natural resources seemed to be inexhaustible, and waste, an accepted by-product of production processes, was washed away, carried off by the wind, or buried where it did not come into visible contact with communities. In the late 1960s, however, Americans became aware of the results of this waste ethic. They recognized not only that resources were finite but that their use sometimes had adverse effects. Public outcry drove the government to enact legislation and promulgate policies aimed at rectifying these problems. Industry responded to the threat of punitive action and has taken steps to address environmental issues. Most corporate leaders concede that the government's approach was warranted and that industry had abused its privilege but maintain that industry has since corrected its behavior and that the government should change its approach. The industrial sector today contends that environmental values have become an essential dimension of responsible personal and corporate behavior and that external pressure to change is no longer necessary. Although industry exists to make a profit, it recognizes that the profit motive must be accompanied by responsible approach to the environment.

Every industry we visited during the course of our study has taken steps to address environmental concerns, although the motives vary widely. We have characterized the environmental aspect of industry as being international in scope, driven by government regulation, diverse in environmental protective practices, dictated by economics, and focused on

technology for solutions. It is in this framework that we look at specific examples of the impact of environmental issues on industry.

International Scope

The international aspects of environmental issues with respect to industry are twofold: the environmental impacts of industrial processes transcend national boundaries, and corporations are increasingly global and must comply with multiple environmental regulatory systems.

The global economy is alive and growing, and the progress of humanity is increasingly discussed in the context of the global village, but collective responsibility for the earth's environment has not yet struck a resonant chord. Most environmental initiatives appear to have a national focus dictated by the application of government regulations, the immediate effects on the local populace, the economic health of the enterprise, and the cost and technical viability of alternative approaches.

Shared water and air resources can make environmental issues matters of national security, which became most obvious when the Chernobyl nuclear reactor spread radioactive contamination across Europe westward from Russia to Sweden. While this incident forced the world to recognize environmental interdependence, nations still choose to overlook pollution issues in the interest of addressing more basic priorities. This problem is more pronounced in nations that are trying to develop market economies. In Poland, for example, the primary energy source for generating electricity is brown coal, a significant producer of harmful emissions. While there is concerted action to reduce the impact on the local environment, concern over the overall atmospheric degradation is mitigated by the economic benefit and the fact that 70 percent of the hazardous emissions leave Poland. Even nations with developed economies can have a somewhat myopic view of their global obligations. An industry spokesman in France indicated that it would be perceived as an inappropriate intrusion into internal affairs for other countries to raise objections about industrial practices in France. The United States, in spite of significant resources and environmental enlightenment, still uses coal-fired power plants that emit large amounts of greenhouse gases that are tied to global warming.

The second aspect of international environmental issues is that transnational corporations are responsible for complying with multiple sets of national environmental regulations. Industrial giants like General Motors, Grace-Davison Chemical, Dupont, Wacker-Chemie, Siemens, and ELF Aquitaine produce and market their products worldwide, and to be successful they must comply with environmental standards wherever they do business. This is accomplished through different levels of clean-up, pollution control, and environmentally oriented manufacturing processes in each location, depending on the local requirements. Such an approach often reflects a compliance orientation limited to the specific area of operation rather than a true environmental ethic based on the knowledge that the industrial process has a global environmental effect.

Government Regulation

We have determined that industry as a whole has been spurred to act on environmental issues by government legislation and regulation. Examples of neglect and inaction were widespread in the United States throughout the 1970s and continue to exist in eastern Europe today. Where environmental regulation has been passed and enforced, cleanup is occurring and practices improving. Over the last 30 years the United States has made , significant progress, and environmentally responsible practices are now the norm. This is true in western Europe as well, but eastern Europe is only beginning to make meaningful progress.

In developed market economies, industry as a whole is complaining of overregulation, heavy economic burdens that are not justified by limited benefits, and government supervision made unnecessary by industry's acceptance of environmental responsibility. These are legitimate concerns, but the fact remains that the environmental decline of the past would not have been reversed without government intercession and control.

The developing economies of eastern Europe face significant challenges. Newly emerging and struggling governments are burdened with a legacy of pollution and contamination at a time when budgets will not support more than basic services. These same governments are reluctant to make decisions that might jeopardize jobs and income by restraining or

penalizing industries that are, or will be, polluting. Not only do old ways of operating resist change, but the politics of balancing priorities means that environmental issues will lag economics, which will have top priority in eastern Europe for many years. Although market acceptability in the European Union may dictate "environmental correctness," substantial acceptance of and action on environmental issues will be lacking for some time to come.

Diverse Environmental Protective Practices

Industry's efforts to protect the environment, regardless of whether they are stimulated by compliance with government regulations, by the quest for higher profit margins or by environmental altruism, can be divided into three categories: remediation, end-of-pipe pollution control, and process improvement.

Remediation. In remediation, industry attempts to clean up environmental pollution that has already taken place. The primary example is cleaning contaminated soil, usually of petroleum, chemical, heavy metal, or radioactive waste. Remediation is most frequently seen in areas where past practices resulted in contamination of the soil and groundwater; however, spills today can result in emergency remediation requirements.

The U.S. Department of Energy Hanford Operations Office is perhaps the mother of all remediation efforts. In 46 years of processing nuclear materials for the nation from 1943 through 1989, the 560-square-mile Hanford site generated about 350 million liters of high-level radioactive waste, and radioactive materials and hazardous chemicals contaminated 64 million cubic meters of soil and 2.7 billion cubic meters of groundwater (about 200 square miles). This facility is the largest single contaminated area in the United States. Today, the mission of the site is environmental clean-up and storage of contaminated waste. The remediation effort, which is projected to take 30 more years and cost approximately $40 billion, involves two major contractors in everything from removing, treating, and disposing of contaminated liquids, to performing vitrification of contaminated soil, to demolishing and storing radioactive facilities.

For example, Simpson Tacoma Kraft remediated 17 acres of intertidal harbor in Puget Sound by sealing and covering years of bottom contamination with soil materials that have fostered a resurgence of the marine ecology. Grace-Davison Chemical's remediation of 49 sites, at a total cost of $216 million, includes such actions as recontouring and capping hazardous waste piles, removing contaminated soil, closing underground storage vessels, and reclaiming sites.

Pollution control. End-of-pipe pollution control involves capturing hazardous by-products that are inherent in a production process before they can be released into the environment. Scrubbers, bag-houses, and wastewater treatment plants are examples of this type of protection. This approach still produces hazardous waste, but it is controlled and disposed of in less harmful ways. Innovative companies may even recycle the waste back into the production process or into another product line. The efficiencies inherent in recycling the waste may offset some of the cost of the pollution prevention or even generate additional profit.

Standard end-of-pipe mechanisms were in existence in every industry we visited, from scrubbers at the Belchatow Power Plant, to bag-houses at Eastalco, to wastewater treatment plants at General Motors, Skoda Plzen, and Grace-Davison. End-of-pipe pollution control is not unusual, and in fact its absence would be the exception. What is unusual is the innovative uses for captured by-products that were formerly waste materials but have become raw materials. We saw examples of this at the Belchatow Power Plant (gypsum resulting from the combination of sulfur and lime in scrubbers providing raw materials for wallboard and concrete), Grace-Davison (recycling of plastic waste into new products, silica waste into sodium silicate [a raw material] and ammonium nitrate back into the chemical production process), Dupont (chemical and plastic waste into new products), and the Texaco Anacortes Refinery (sulfur waste sold as raw material for fertilizer).

Process improvement. The third industry approach to environmental protection is modification of the production process to reduce or eliminate pollution and waste. The possibilities are endless; examples include substituting materials, changing the physical manufacturing process, upgrading equipment, and changing packaging materials. For example,

Grace-Davison burns plastic waste to generate steam for its manufacturing process, and General Motors substituted a nonsolvent based adhesive for one that was causing the release of 300 tons of hazardous emissions a year.

Economics

Industry pursues those practices that will increase profits and avoids those that reduce profits. In the past, efforts to protect the environment were to be avoided because they would have resulted in additional expense. Beginning with the passage of environmental legislation in the 1970s, industry's objective became to avoid environmental damage because it resulted in punitive fines and directed clean-up--both of which would have a negative impact on the bottom line. Industry has begun to find that it can actually increase profits in the process of pollution prevention. In end-of-pipe pollution control, profit can result from recycling hazardous materials back into the production process or by using waste as raw materials in new product lines, in both cases reducing raw material costs and avoiding disposal costs. When industry modifies production processes in order to prevent pollution, process improvements that prevent pollution frequently result in greater efficiency in production as well. Therefore, while industry may have initially viewed environmental protection as a cost avoidance measure, it is now increasingly viewing pollution avoidance as an income generator.

Technological Solutions

When faced with the requirement to meet environmental regulations, industry has looked for technological solutions rather than scrapping processes entirely. This approach has been largely successful but uneven across industry as a whole. In the chemical industry, for example, technology has provided solutions in the manufacturing process, the handling and transport of materials, the processing of waste, the use of waste materials as raw materials for new products, and the substitution of materials. The petroleum refining and mining industries, on the other hand, has limited its use of technology largely to containment of pollution.

CHALLENGES

In general, much of industry does not argue about the virtues of environmental protection. However, a challenge for industry is to deal with the way the government requires it to protect the environment and the degree to which government requires it to do so.

In an era of rapid change, when industry must be particularly agile in order to remain competitive, bureaucratically cumbersome and prescriptive regulations can be a fatal handicap. For example, the EPA intends to require potential sources of major pollution to apply for a new operating permit for each facility every time it modifies a manufacturing process. For a computer chip manufacturer, like Intel, that means 30-60 new permits per factory each year. Each new permit requires several hundred pages of data specifying the operations and the amounts of actual and potential emissions. The permit action requires 30 days for public comment, 45 days for EPA to object, 90 days for revisions to be considered, and 60 days for citizen petition. In the information technology business, delays of this length would be devastating. Without modification of the requirements, Intel could choose to relocate to a less regulated country.

A further criticism by industry is its perception that regulations work against the environmental outcomes they were designed to accomplish. By dictating specific technologies for pollution prevention, the government has regulated against the development of new products and processes and established the status quo as the only acceptable standard.

Other industries believe that correctly focused regulation may actually stimulate innovation and competition, particularly among the most technologically dynamic firms. If regulations require achievements that can only be met through radical technology breakthroughs, then industry is spurred toward innovation. When coupled with government support and incentives, this innovation can earn a profit for industry and obtain a cleaner environment for society.

Industry is also concerned about the level of environmental protection required. In the areas of air and water pollution, industry contends that the

standards are unnecessarily high, that the 90 percent improvement that has been accomplished is sufficient, that the last 10 percent would not be substantiated if subjected to a cost-benefit analysis, and that in some cases the standards for industry emissions are higher than conditions that exist naturally.

GOVERNMENT GOALS AND ROLE

Environmental issues touch every segment of U.S. society. Individual citizens are concerned about the impact of pollution on health and the quality of life as well as the economic cost of environmental protection. Industry has a significant stake in environmental regulation and how it affects corporate image, shareholder attitudes and, ultimately, business profitability. The government must balance the interests of all in order to protect the rights of the individual, maintain the welfare of the whole nation, and establish conditions conducive to sustaining economic prosperity. This task is complicated by the necessity to promote economic strength, which requires the development and utilization of resources. Environmental decisions and resource use today will determine the fate of future generations. Simply stated, the government's role is to ensure sustainable development.

Background

From the late 1960s through the early 1970s, Americans became aware of and alarmed about their deteriorating environment: life-threatening, visible smog; hazardous waste dumps intermingled with residential communities; rivers devoid of life and polluted to the point where they burned; and depletion and extinction of bird, animal, and fish species as a direct result of human activity. There was widespread public demand for government action to repair the damage and to prevent its recurrence. Congress responded to this clamor by passing the first National Environmental Policy Act in 1969, followed by a flurry of environmental legislation that addressed all aspects of the environment.

The underlying assumption of the legislation was that industry could not be trusted to do the right thing without government intercession; that manufacturers, handlers, recyclers, and users could all be assigned blame

for pollution; and that industry required a watchdog to police, investigate, cite, and punish. Litigation rather than negotiation was the modus operandi. Regulations were prescriptive in nature, not only specifying the required results, but dictating the technology necessary to achieve those results.

The EPA.. The idea of reforming the federal government's approach to pollution by consolidating diverse and disparate programs and bureaus into one federal agency had widespread support and resulted in the formation of the EPA in 1970 (Cook, 1989, 81-87). The EPA is different from other federal regulatory agencies in that the scope of its mission holds it responsible for the entire spectrum of industry. Consequently, EPA personnel must develop a broad understanding of multiple industrial processes and environmental impacts that cover industry as a whole. Additionally, the EPA is required by law to disregard cost in determining the safety standard that allows an acceptable risk and is in the best interests of society. The agency has been routinely constrained by policy conflicts between Congress and the executive branch. Congress has set ever more stringent environmental goals and deadlines that have emphasized discrete problems and policies rather than holistic solutions. Presidents, on the other hand, have had to balance environmental initiatives with a need for economic stability and growth.

Policy. The first administrator of the EPA, William Ruckelshaus, implemented an aggressive strategy to enforce the new air- and water-quality laws that led to adversarial relations with industry through the 1970s and the 1980s. Government regulations through the 1990s have been largely command-and-control oriented, implemented without regard to cost, and enforced against large industrial corporations. In the 1980s, industry began complaining about EPA's micromanagement and the command-and-control approach to implementing environmental regulations.

In the early 1990s, three events initiated a campaign for change in the federal government's approach to its role as environmental protector. First, the 1990 Clean Air Act amendments vastly widened the requirements for emission controls, affecting small businesses such as dry-cleaners, garages, auto body shops, painting contractors, and bakeries

as well as faceless corporate boardrooms. Second, a continuing economic malaise caused both the government and individuals to question the economic cost of environmental regulations. Finally, in 1992 Congress passed the Federal Facilities Compliance Act (FFCA), which mandated that government agencies follow the same environmental regulations and standards that industry did. All executive agencies thus had to factor environmental standards into their budget requirements. On the regulatory side, the EPA was forced into a position of enforcing fines and penalties against other federal executive agencies. This tense relationship added to the government's recognition that environmental regulations and the methods of implementing them needed to be revised.

By the mid-1990s, federal, state, and local governments, large and small businesses, individuals, and even most environmental organizations recognized that a change in philosophy of environmental implementation was required.

The Perspective of Industry

There is a consensus among businesses on four broad areas in which government reform is necessary:

1. Results-oriented, flexible regulations: the government should establish goals but allow flexibility in the means to attain them.

2. Good science, sound risk assessment, and intelligent risk management: the government should acknowledge that there are priorities in managing environmental risks. Governments at all levels should assess environmental risks in order to minimize the more important ones and make effective use of scarce resources.

3. Positive cost-benefit ratios: The value of the benefits that come from the regulations should exceed the cost of the regulations. The total cost to society should be estimated and weighed.

4. Encouragement of market-based approaches: industry has long known that innovation snowballs and creates its own momentum.

A Cooperative Effort for the Future

Environmental issues affect industry primarily through the government's interpretation of what is necessary to protect the environment and how that protection is to be implemented. The current complaints from legislators, industry, and individuals that the government's approach is now outdated have a legitimate basis. While industrial motivation to protect the environment may not be completely altruistic, the growing awareness that profitability and environmental protection are connected may itself be sufficient to cause industry to "do the right thing."

Environmental protection is too critical an issue for society and future generations to leave to trust and good faith alone. The government will continue to have a role in ensuring that environmental standards provide adequate protection and that industry is in fact meeting those standards. Rather than a stripping away of environmental regulations, what is needed is a new regulatory framework to give industry more flexibility in preventing pollution--but only if industry can do what is required under the current system of strict safeguards.

Environmental quality should be the touchstone that brings the United States together as a nation rather than a group of contentious issues that causes further polarization. The goal should be to prevent pollution, not just clean it up. By using financial incentives instead of dictates to discourage pollution and by putting more emphasis on results and less on how they are obtained, the United States can ensure more effective pollution prevention at lower costs. Flexible regulations must be coupled with accountability and enforcement to ensure the safety of both the environment and the public health.

Environmental solutions for the future must be the result of cooperative efforts between government and industry. The government must guard the environment and public health, but industry can and should be a willing partner rather than an adversary. The way to form such a partnership is to reach the broadest possible consensus on what constitutes adequate environmental protection and let industry harness its efficiency and ability to innovate to produce the best possible solution. Even when consensus on standards cannot be achieved, flexibility on methods to achieve them will

significantly improve the cooperative environment. Basically, the process will work better if "government steers and industry rows."

The Systems Approach

The piecemeal approach to environmental protection means that changes in standards or methods in one area of the environment may actually degrade another. For example, rejecting nuclear power as detrimental to the environment may lead to increased use of coal-fired power plants, which will increase the level of emissions that can be as harmful as nuclear wastes. Government and industry must look at the environment from a holistic perspective. A systems approach will help prevent situations in which the government passes conflicting regulations or enforces methods that actually degrade the environment rather than improve or protect it. It will also increase industry's awareness tires to improve the environment with methods that meet one standard but not another.

A Unique Opportunity for Government

The 1992 FFCA has had a discernible effect on the Department of Defense (DoD). The DOD's size and power are significant, but it is not often thought of as a landowner and operator of a large industrial complex even though it employs approximately 3 million people worldwide and manages 25 million acres of domestic land holdings and 2 million more acres overseas. Most military installations contain complex, city like developments of industrial, commercial, and residential areas and the equivalent of national parks, recreation areas, forests, and deserts. The size of its land holdings alone makes the DoD one of the largest industrial complexes and environmental managers in the United States. Prior to the passage of the FFCA, the typical attitude of a military base commander might have been: "We're in the business of protecting the nation, not the environment. Why should money be spent on the environment rather than operations or training?" Portions of nearly every U.S. military installation had been contaminated with hazardous waste that varies from acids and fuels to low-level radioactive waste. Like the civilian sector, the military used methods to handle, store, and dispose of hazardous waste that were acceptable at the time but now are considered environmentally unsound.

The DoD has identified 10,439 suspected hazardous waste sites on active military installations, and more than 100 DoD facilities are on the EPA's Superfund List.

With the passage of the FFCA, the government waived sovereign immunity, subjecting itself to the same conditions to which it subjected commercial industry. Through its operating agencies, the government, like industry, must now contend with the same legislative and EPA bureaucracies, lawyers, courts, permits, and fines, and, perhaps most important, with balancing how it commits limited (and dwindling) resources when environmental requirements conflict with operational needs.

Under these conditions, the government has a unique opportunity to be a role model for industry in protecting the environment. Agencies such as the DoD are equal to industry when it comes to compliance with environmental regulations, and the conditions under which those agencies must operate now parallel those in the private sector. Those government agencies now have the opportunity to demonstrate the ethic and the industrial efficiencies necessary to comply with government environmental requirements. The fact that the agency that enforces environmental regulations and the agencies that must follow them are both in the executive branch of the federal government provides a controlled environment of sorts. If standards or regulatory requirements are inappropriate, *regulated* agencies can identify them as such, and the *regulating* agency can lead the effort to get them changed.

A Life-Cycle Approach

Environmental concerns first began to affect industry in the form of remediation of past contamination. As the environmental, health, and financial costs of remediation were determined, it became evident that prevention of the contamination before it occurred was fiscally and environmentally necessary. As industry faced continuing problems in disposing of hazardous waste materials, it pursued process improvements to prevent the production of waste. This quest to make processes more efficient must be applied not only to production portion but also to the use of the product and its ultimate disposal. As in the case of automobiles, the

use of the product will continue to be a significant pollution source even if the production process produces no hazardous waste. In the case of some products, such as nuclear fuels, the disposal of old materials presents the most significant threat to the environment. Both industry and government must shift their focus from individual segments to the entire life-cycle. Both must assess the environmental impact of the production, use, and disposal of a product and ensure that the public and the environment are fully protected at each stage.

CONCLUSIONS

Environmental concerns are a matter of strategic importance for this nation because they involve issues that affect global stability and the continued progress of humanity. The need for sustainable development represents a serious challenge for both industry and government. The United States can continue to improve its environmental health by implementing four actions:

1. Develop a systems approach to government regulations and other environmental actions.

2. Adopt a life-cycle environmental approach to industry processes and products.

3. Make government agencies role models for industry in environmental practices.

4. Establish a cooperative partnership between government and industry for environmental protection.

These recommendations are specifically oriented to the impact of environmental issues on U.S. industry. In spite of the improvements these actions can bring about, relative to the environmental problem overall they will not represent significant progress. The truly difficult challenges lie in implementing a global approach to environmental problems that arise from industrial activity. Furthermore, environmental issues involve far more than industry. Individuals need to make a concerted effort to be responsible stewards of the earth's riches. The environment is a common

treasure for which all people bear responsibility. Until these changes occur, environmental issues will continue to challenge human survival.

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FINANCIAL SERVICES INDUSTRY STUDY REPORT 1996

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Office of the U.S. Trade Representative, Washington, DC
Board of Governors of the Federal Reserve System, Washington, DC
National Association of Securities Dealers, Washington, DC
World Bank, Washington, DC
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Wall Street Journal, New York, NY
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Citibank, London, UK
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ABSTRACT

As nations manifest their international power via economic rather than military assets, a nation's ability to raise and distribute capital and to assess, market, and spread risk becomes more important. These capabilities are fundamental to all economic activity, and a nation's achievements in these areas significantly affect its productivity and economic performance. Accordingly, it is important to objectively assess the threats, opportunities, and international competitiveness of the world's financial services sector in order to determine its relative importance to the U.S. industrial base and national security.

INTRODUCTION

Today, a nation's ability to compete in the international arena is inexorably linked to its ability to manage its finances. As the economic aspect of national power increases in importance, no nation can be truly secure if it cannot compete economically. And to compete economically, a nation must project an image of financial stability and be able to take an active role in world financial markets. The adage Amoney makes the world go round" has never been more true than it is today, but today money is being used more and more as a key aspect of national security strategies. How a nation, particularly the United States, manages its finances and becomes a successful player on the world financial scene is the subject of this report.

Today's financial environment features high interdependence and a global nature. Various nations, financial institutions, and in some cases national and international regulatory bodies make the system work. This report focuses on key elements of U.S. financial services, their interactions, emerging trends and issues that will affect the industry in the years ahead, and links between financial services and U.S. national security.

For the study, members of the financial services seminar read widely on financial services and discussed relevant issues during a series of seminars, each targeted at a different aspect of financial services. We researched domestic laws pertaining to financial services, trends in the United States's ability to manage its finances (for example, U.S. monetary policy), and the role of key institutions in the global financial environment,

and prepared research papers, the key findings of which are contained in this report. Finally, seminar members visited a variety of organizations in the United States and Europe that participate in and help shape the world financial system, such as stock exchanges, central banks, large U.S. investment and commercial banking institutions, financial news services, regulatory agencies, advocacy groups, "hometown" banks, and savings and loan (S&L) institutions.

THE FINANCE INDUSTRY DEFINED

Financial services are provided by myriad institutions that continue to expand as the sector continues to diversify. Domestically, three key industry groupings, banking, securities (also referred to as investment banking), and insurance, each contain a variety of institutions.

Banking

The major institutions in this group are commercial banks and S&L associations. *Commercial banks*, the institutions that most people deal with every day control the payments system by clearing checks and drafts and providing other basic financial services. *S&L institutions* are similar in terms of service but tend to have a much smaller geographic focus and rely more on personal contact and their stature within a community to generate business.

Securities (Investment Banking)

This sector is made up of the world's investment banks and brokerage houses, the vast majority of which are located in the United States. Key activities include securities underwriting (raising capital through the creation and sale of new securities, both equity [stocks] and debt [bonds]), secondary market activities (executing securities transactions for retail and institutional clients such as pension funds), proprietary trading (trading securities for the bank's own account), mergers and acquisitions (e.g., participation in leveraged buy-outs.), asset management for wealthy clients, and analytical services.

Insurance

This sector contains companies generally associated with selling various types of insurance. But insurance companies no longer occupy the neat, well-defined niche in the financial services sector characterized by agents plying an assortment of whole, term, and health policies. Increasingly, savvy investors have unbundled their life insurance, opting to purchase relatively low-cost term policies and investing the difference in other, higher-yielding (and often riskier) financial instruments such as stocks and mutual funds. In response, the insurance industry has begun to offer new, more innovative products such as universal life policies and has ventured into the business of marketing derivatives--futures and options--to hedge risk. These products offer a new source of capital and give insurers the prospect of expanding coverage to currently uninsurable risks.

Internationally, insurers are moving more towards the reinsurance business--in effect, insuring the insurers--in order to minimize risk. This tactic prevents any one insurer from having to carry an unacceptable level of risk, which allows companies to insure additional clients. The move to reinsurance also allows more entrants into the industry in general, and, it is hoped, will lead to more competitive prices.

Regulatory Bodies

Domestically, much of the current regulation of financial services has its origins in the period following the Depression more than 60 years ago. At that time the U.S. government placed distinct limits on financial institutions by segmenting financial markets into the three industry groupings described above.

In addition to four federal agencies, 50 state banking commissioners supervise all state-chartered commercial banks, savings banks, and thrifts. National banks are supervised by the Comptroller of the Currency. The Board of Governors of the Federal Reserve System regulates its members, state-chartered banks, and all bank holding companies. The Office of Thrift Supervision regulates federal and state-chartered thrifts. The Federal Deposit Insurance Corporation regulates state banks not in the Federal Reserve System and assists in regulating national banks and state-chartered member banks.

Securities underwriting and sales are regulated by the Securities and Exchange Commission (SEC), an independent, nonpartisan, quasi-judicial agency. Using legal sanctions where necessary, the five-member commission (appointments are subject to Senate confirmation) administers federal laws seeking to ensure that securities markets are fair and honest. SEC staff administer laws written to ensure the disclosure of significant information required for informed investment decisions by the public. The SEC does not guarantee that investment offerings are of value or will be profitable, just that the information essential to making an informed investment decision is properly disclosed. The actions of securities brokers and dealers, publicly held entities, investment companies and advisors, and other participants in the securities market are subject to SEC supervision. In this regard the SEC reviews the performance of self-regulating organizations that run national securities exchanges. Individual U.S. states also regulate securities trading and insurance underwriting and sales within state borders.

International Organizations

The International Monetary Fund (IMF) was born out of the idea that nations working together to increase economic welfare could enhance the likelihood of political peace. The IMF's regulatory function was originally to keep exchange rates stable, ensure orderly exchange arrangements, avoid competitive exchange depreciation, and ensure a liberal regime of international payments through the convertibility of currencies and freedom from exchange restrictions (De Vries, 1986, 15-16). Over time and with the breakdown of the system of set exchange rates and convertibility of dollars into gold, the IMF has changed from a regulator into a lender.

The IMF's partner organization, the World Bank, has two tasks: reconstruction and development loans. These are funded primarily from the world's capital markets (unlike the IMF's member-capital-funded operations). The Bank is therefore also interested in a country's creditworthiness based on both external factors and the country's economic policies (Polak, 1994, 1-5). The merging roles have drawn some criticism, but the IMF maintains a relatively short-term focus while

continuing to expand its dealings with developing nations and microeconomic issues.

Other, regional organizations support reconstruction and development in specific geographic areas. For example, the European Bank for Reconstruction and Development targets former command economies trying to make the transition to a market-based system. Similar organizations exist for Africa, Asia, and South America.

CURRENT CONDITIONS

As it moves into the 21st century, the financial services industry is being rapidly transformed by advances in communications and computer technology, resulting in an increasingly competitive and dispersed marketplace, and by new products. "The traditional financial market products--bank credits and 'plain vanilla' debt and equity underwritings--have been overshadowed by financial instruments of greater complexity . . . derivatives, options, index products, asset-backed securities and myriad other innovations" (Hayes, 1993, xi).

A healthy market has a mechanism that enables the financial system to share and pass information about bonds, stocks, and other investment instruments to a society's savers and investors in order to assist them in portfolio allocation decisions. Securities market institutions such as investment banks, stock exchanges, and brokers fulfill this role in the United States. They enable financial markets to operate smoothly, thereby facilitating domestic and international investment in key product and service sectors. Blanden (1995, 22) has noted that "there is no doubt that securities underwriting will in general terms be opened up to the banking industry; while securities will be able to adopt banking status . . . . Still to come [is] letting banks into the insurance industry and allowing non-financial companies to invest in or own banks."

Proposed legislation involving the finance industry revolves around attempts to repeal the Glass-Steagall Act or to allow more freedom of movement in the industry. The struggle among the interest groups (i.e., commercial banks, investment banks, insurance companies, local savings banks, consumer groups, industry associations) will not be resolved soon. The continuing, de facto movement toward increased deregulation was

highlighted by the April 1996 Supreme Court decision to allow banks to sell some types of insurance in certain markets and to allow commercial bank-owned companies and commercial bank personnel to sell securities, annuities, and stock mutual funds.

The legislative changes affecting the finance industry are balanced against certain industry requirements generated both internally and externally. Internally, all financial institutions strive for a healthy level of profitability, assisted today by the relatively more conservative nature of the industry (brought about in response to such recent "shocks" as S&L bailouts and the derivatives "scare") and the enormous profits generated by the credit card business (not found in some non-U.S. banks). Externally, these institutions have to deal with customer concerns regarding security and privacy for those wishing to use computer banking and on-line stock trading services--a pressure that will surely continue to grow.

Internationally, these same institutions must be prepared to compete on a global scale as trade barriers fall and competitiveness increases. While U.S. financial institutions are still the clear leaders in the financial services industry, their leadership is under pressure as foreign financial institutions, many with the help of user-friendly national laws, expand their international presence.

CHALLENGES

Five key challenges facing the financial services industry are the rise of mutual funds, the U.S. saving rate and public sector deficit, the increasing complexity of financial instruments, the use of new technology, and the increased use of quick international transfers.

The Rise of Mutual Funds

Americans have increasingly sought to make their own decisions about risk and return. Moreover, they want convenient services and technology and information that will allow them to achieve their financial goals (Szabo, 1994, 22-24). These desires have underpinned part of the seismic shift to the mutual funds market. In 1980, investors could choose from among 564 funds. Today, 10 times as many funds embrace different

investment styles and asset categories. In the past 10 years the value of the mutual fund industry has grown from about $500 billion to $2.6 trillion ("Wall Street," 1996, 6). Tired of low interest rates at banks, average workers are looking for higher returns on their investments. Unfortunately, most workers, despite great confidence in their investment capabilities, lack the most rudimentary knowledge about the way their 401(k) pension fund works or the risks of the investment vehicles they are using. Even individuals who believe they are seasoned investors really do not understand funds and basic investing principles (Updegrave, 1996, 98).

With workers putting all their eggs in the mutual fund basket, the big questions become, what will happen if the stock market does not continue to climb? Should a business that has no insurance safety net other than public confidence have more stringent controls? Are investment funds managers managing funds for their own gain or for the fund's shareholders? What is the role of proprietary trading?

And what about market influence? Currently the Fidelity fund family controls about $550 billion of stock. On any given day, Fidelity accounts for 10-15 percent of the volume on the New York Stock Exchange. The sheer size of Fidelity, whose multiple families of funds buy and sell the same stock, can place incredible pressure on the market. At the end of September 1995, for example, Fidelity owned 12.22 million shares of Motorola. During October and November it sold approximately 8 million shares, driving that stock down 18 percent (Fromson, 1996, A1, A18). Substituting a critical defense company or a foreign-controlled investment fund for Motorola leads to intriguing implications for possible damage to the industrial base.

The U.S. Saving Rate and the Public Sector Deficit

> *In 1900 only one in twenty-five Americans was over sixty-five. The vast majority of these people were completely self-supporting or supported by their families. By 2040 one out of every four or five Americans will be over sixty-five, and the vast majority will be supported to some degree by government entitlements.*
>
> (Peterson, 1996, 57)

In 1993 Americans saved only 5.4 percent of disposable income, and in 1996 private saving is around 5 percent after taxes. In contrast, private saving in Germany, Japan and South Korea is in the range of 12-30 percent. The situation is considered so grave that last year the Labor Department spent $2 million on a campaign urging Americans to save more.

Personal saving rates have decreased over the last four decades. The 1950s saw a rate of 6.8 percent, the 1960s of 6.7 percent, the 1970s of 8 percent, the 1980s of 5.4 percent, and the early 1990s of 4-5 percent. To explain the decline in personal saving, some claim that the rate does not account for all the ways Americans save. Since a nation's total rate of saving equals private saving plus government saving, Americans could be saving more than the numbers indicate. A 1989 Federal Reserve Board study that used a broader gauge of what constitutes savings concluded that the real 1980s savings rate was closer to 12 percent. If involuntary saving--government "forced saving" such as personal and employer taxes paid to fund Social Security, Medicare, and Medicaid and employer contributions to health and pension plans--are taken into account, the rate is even higher.

Changes in the availability of credit have affected saving patterns. Credit cards and loans, once used for emergencies and convenience, have become a source of capital to fund a higher standard of living by making it easy for Americans to purchase items for immediate consumption. Baby boomers (who head 41 million U.S. households) allocate three times as much income to debt other than mortgage (23 percent) as to retirement savings (7 percent). Another 26 percent is allocated to mortgage debt.

The failure of Americans to save enough for their own needs will make it more difficult for them to retire, and the problem will compound for each succeeding generation. A growing retiree population, increasing longevity, rising health care costs, and a shrinking work force could have devastating consequences for the future of the United States. Currently there are 3.4 workers for each Social Security beneficiary. In 2035 the ratio could be as low as 1.9 to 1, which could have dramatic consequences for national cohesion, standards of living, tax rates, and the ability of future U.S. workers to save for their own needs.

The federal government drains off a large share of the already low pool of private savings available for domestic investment. In the past decade government spending and trade deficits have strangled domestic savings. The federal deficit consumed nearly 45 percent of the nation's available private savings in 1994. The larger the deficit grows, the less freedom of action the government will have to spur growth without fueling inflation and long-term interest rate increases. More important, a low saving rate coupled with twin deficits (i.e., trade and government) may affect long-term national security.

The United States has become a net importer of capital. Reliance on foreign capital places pressure on interest rates needed to attract investment and results in capital outflows to foreign debt holders in the form of interest payments. The higher the reliance on foreign savings, the more risk the United States takes in finding finance.

The Increasing Complexity of Financial Instruments

Increasingly complex financial instruments cover new areas. For example, derivatives are financial contracts whose value is tied to some other underlying asset, such as currency, an equity, another commodity, or an indicator like an interest rate or index--that is, their value is derived from some other tangible asset. A derivative, much like an insurance policy, is a financial instrument designed to separate some of the risks associated with an investment from the investment itself. Once isolated, the risk can then be transferred to someone willing to assume that risk (for a price).

Investors and fund managers routinely use derivative securities to hedge against investment risks, leverage their investment potential, or speculate on different types of securities. The most common types of derivative securities are futures and options, which are contracts to buy or sell shares of stock (or a commodity) at a specified price on a specified date. While companies can buy and sell futures and options as part of their financial portfolios, they are more likely to use derivative contracts with major investors, banks, or insurance companies to transfer some of the risks of their projects (and rewards) in order to craft a more predictable profit margin.

These types of arrangements are usually *not* publicly traded securities on the major financial exchanges. They are usually not very liquid. A key point is that they are not necessarily derivative securities--just derivative agreements. Therefore most of these transactions are not subject to the scrutiny of the SEC or any of the major market self-regulatory bodies. But the problems with derivatives seem to stem from a failure on the part of investors to fully understand the risks involved. This failure may be due not to the increasingly complex nature of these investments but rather to the failure to ask tough questions about risk, value, exposure, and accounting practices.

Clearly some regulation is needed to require publicly held companies, mutual funds, and municipal governments to disclose to their shareholders the inherent risks of the derivatives held. Full disclosure will allow investors to decide for themselves whether or not a particular company or fund has an acceptable level of risk. Investors with a high tolerance for risk may seek out highly leveraged companies and funds. But investors with a low tolerance for risk should not be misled into funds that appear safe but are actually quite speculative.

While derivatives have gotten a bad name, when used prudently they are an effective way for companies, funds, and money managers to reduce risks. They offer companies the chance to isolate risks associated with future cash flows, interest rates, and other variables and ensure steady profit margins.

Use of New Technology

The transition to electronic commerce in the domestic retail sector is occurring in three phases. The technology for each phase is in use, and consumer acceptance builds on the success of earlier phases.

Phase One. Automatic teller machines (ATMs) and telephones have made remote distribution possible and are well established.

. 40 percent of U.S. mutual funds are distributed via phone and mail.

. 57 percent of U.S. banking transactions take place outside the branch (24 percent by phone and 31 percent by ATM).

- Nearly 20 percent of consumers visit their bank branch less than once a month.

Phase Two. The use of the personal computer (PC) combined with information reporting through on-line network services is growing rapidly, although the full impact, which will be profound, at least for technoliterate users, is several years off. Over 30 million U.S. households, including more than 60 percent of the top income quintile, own PCs, and more than 20 percent of PC owners manage their financial affairs on their PC. While widespread acceptance of phase two is some years away, attractive segments of affluent customers are progressing much more rapidly. Financial institutions are taking action to position themselves for the next phase of the industry's evolution.

Phase Three. Electronic cash (E-cash) and interactive video--digital money-- are the ultimate money exchange medium for an increasingly wired world. E-cash will evolve in two areas: (1) the continued development of secure ways to use on-line transfers and (2) the development and acceptance of an "electronic wallet" that will allow convenient transport of small amounts of cash for typical purchases. Combining purchase convenience with information will have significant effects on financial services and other industries.

The widespread use of E-cash will make geographic presence obsolete. Customers will not need to visit local branches to make deposits and withdrawals. ATMs will not need to be stocked with cash. Instead, consumers will be able to obtain E-cash in their own homes via phone, PC, or dedicated terminal. Before E-cash becomes a widespread medium for money, however, significant conceptual problems must be solved:

- Bank and governmental control of the growth of E-cash systems.

- The digital security of E-cash versus the physical presence of notes and coins.

- The possibility that E-cash will widen the split in U.S. society between the haves and have-nots. Only those who can afford the technology would have easy access to it.

- Threats from computer hackers, information warriors, counterfeiters, money launderers, and tax evaders.

Current interactive video technology is cumbersome and costly, but future developments will make the technology more user friendly and cost effective--allowing a full suite of financial services on interactive video to be extended to the office or home.

The use of new technology in commodities and stock markets is unlikely to soon replace human involvement in floor trading operations. The exchanges are still protective of their "open auction" price discovery methodology and cite the necessity to see another human being when making a trade. New technology (e.g., new flat-panel screens on trading floors and automated systems for trading outside normal hours) will be used to assist rather than supplant traditional methods until exchange owners are confident that new technology can provide more effective, cheaper, and faster operations.

Quick International Transfers: "Hot Capital"

The increasing propensity of capital to move freely in search of high returns and security presents different challenges for investors, businesses, and governments. International capital transactions and foreign exchange fluctuations affect every nation that plays in the global economy. Markets assess a nation's economic policy or a business's performance and react quickly. Investors need to be constantly aware of this information and its effect on the risk or return of their investment. Businesses and governments may find that market assessments change the availability of capital (i.e., a flight of hot capital that moves in search of relatively better opportunities), exchange rates, or the cost of financing debt.

OUTLOOK

Domestic

Investors have increasingly been *transferring money from bank accounts to other investment vehicles* such as money market and stock mutual funds. Over the last 20 years, the share of financial assets managed by

banks declined from nearly 40 percent to about 24 percent (Baris, 1994). Between 1983 and 1994, commercial banks' share of total net lending fell 25.2 percent, while their share of total credit market assets fell 20 percent (Reinbach, 1995, 47).

The *number of banks in the United States declined* from a peak of nearly 30,000 in 1920 to under 10,000 in the 1990s, with the top 100 holding 80 percent of asset value. The number of consolidated "megabanks" with a national presence has increased.

Investment banks are facing increased competition from their customers. Many large companies are hiring their own internal financial expertise, which enables them to develop contacts and in-house aptitude that have traditionally been the purview of the investment banker. Increasingly, in merger and acquisition transactions, "more and more companies are shunning Wall Street and are negotiating and completing mergers with little, if any, help from bankers" (Raghavan and Lipin, 1996, A1).

There is *a move from personal to electronic services*. Banking (and financial services in general) in the past was heavily based on individual attention and personal relationships. Electronic investment and banking does not lend itself to such personalized service. Some customers are not willing to do things differently and, when forced, many are finding it difficult to change. Retail banking may become a very disaggregated market serviced by some giant national institutions but retaining opportunities for niche neighborhood or regionally based institutions.

In the next decade *banks aim to become the "one-stop shop" for all financial products* from loans to insurance. Six years ago banks were not in the business of selling mutual funds. However, in 1995 banks sold over 20 percent of the mutual funds sold in United States. If this trend continues, the line between commercial and investment banking will disappear. Some financial institutions have already started working around the Glass-Steagall Act.

International

An increasing number of large, non-U.S. financial institutions--particularly commercial and investment banks--are developing strategies

to compete in the global financial services market. This trend is severely testing the traditional preeminence of U.S. institutions in this market and is contributing to increased competition among large financial services companies for a share of the world market. Since regulations governing financial services differ in each nation, these companies establish strong footholds in the more liberal nations and use them as a springboard for pursuing other opportunities worldwide.

A second identifiable trend is the *opening of previously closed financial markets to more competition* as a result of the World Trade Organization (WTO) agreement on financial services concluded in 1995. While this landmark agreement does not level the financial playing field entirely, it does offer incentives for financial services companies to compete in the international marketplace.

Third, the increased competitiveness in the financial services sector and the increased use of technology to conduct financial transactions has resulted in virtually *24-hour, worldwide trading in almost all financial instruments*. Today, a stock market is always open somewhere in the world, and financial services firms can trade at any time for their customers on one or more of these markets. Institutions often play these markets against each other, hedging their risk on one market while making investments on another. In addition, the rise of these markets has provided additional outlets for raising capital, thereby allowing companies and, in some instances, nations to participate to a greater extent in the world's marketplace.

Finally, much of the world financial community is engrossed in *Europe's efforts to establish a single currency* before the turn of the century. The conversion to a single currency will not be easy, especially given that the "loss" of one's own currency is an emotionally charged issue that transcends both the political and economic advantages of going to a single currency. The cost to financial institutions will be high--some estimates range upwards of $2 billion--but, in general, these institutions favor such a move as it will in the long run reduce costs and add stability to the European financial markets. Many hope then to see the new "Euro" successfully competing against the U.S. dollar as the world currency.

GOVERNMENT GOALS AND ROLE

> *Many analysts hold that excessive public interference will drive down returns on early-stage investments below levels necessary to attract venture capitalists and hence argue that governments should limit their role to assist in setting up the market infrastructure and in creating an environment that is conducive to entrepreneurships.* (Organization for Economic Cooperation and Development [OECD], 1996, 17)

While this statement specifically addresses the role of the government in the venture capital arena, it can be argued that the same approach should be followed for the entire financial services industry. A central bank now has less power than before in directing economies and needs to keep constant watch over other central banks and the worldwide financial markets. The markets assess economic policy and performance and declare results (in the form of foreign exchange and interest rates) with increasing speed. Because the volume of a single day's foreign exchange trading dwarfs the currency reserves of any nation, central banks can only work with and influence, not directly control, market sentiment. As worldwide deregulation continues, cross-border transactions and capital transfers multiply, and new markets emerge, the influence of the market over central banking institutions seems set to continue increasing. One reaction to this trend has been the formation or revitalization of multilateral forums and institutions (e.g., the OECD, the WTO, the IMF), to maintain central bank and governmental influence.

Where the government can continue to play a role is in ensuring that the nation is a stable place to invest. This includes taking action, when necessary, to keep the nation's currency stable in relation to other, possibly stronger, currencies on the world market, developing a regulatory climate that does not stifle capital formulation, and adhering to sound fiscal principles (such as a balanced budget and encouragement of private and public sector saving) that inspire confidence in the country and its economy. In the long run, the government's role should be one of nurturing a broad-based financial framework that helps promote stability and economic well-being.

Public authorities are increasingly aware that fostering venture capital activity is critical to gaining the economic and social benefits discussed earlier. (OECD, 1996, 33)

The government must also continue to encourage increased market access to the broad spectrum of financial services. A great deal of progress has been made in this area, culminating with the signing of the financial services agreement under the 1995 General Agreement on Tariffs and Trade (GATT) negotiations. While the GATT has opened up some additional financial activities to competition, additional steps must be taken to further relax government restrictions on access to financial markets. For example, a worldwide agreement on general accounting principles will help level the playing field and allow any aspiring financial services company or new business desiring to raise capital to compete in the constantly expanding free-world capital markets.

On the international scene, many governments actively encourage their respective financial institutions to participate in the international marketplace through lax (relative to the those in the United States) laws and regulations that clearly favor the development of large, single-source financial institutions. For example, it is no surprise that London, with its "user-friendly" banking laws and history of self- (as opposed to government) regulation, has become the center of financial services for Europe. Likewise, the special relationship between German commercial banks and German industry (a bank often owns upwards of 25 percent of a company it finances) means that the banks have a relatively risk-free investment in Germany, freeing them to expand internationally.

In the final analysis, the goal of foreign governments is to encourage their financial services institutions and create an economic environment that fosters their ability to compete in the international marketplace. While other institutions (particularly U.S. ones) can also take advantage of these environments by establishing operations in other countries, it is clear that many nations see the role of the government in the financial services sector as one of actively supporting domestic financial institutions.

CONCLUSIONS

Our assessment of U.S. comparative advantages and disadvantages in financial services follows.

The United States's comparative advantages in financial services are its ability to raise and distribute capital (particularly venture capital); to assess, market, and spread risk (through commodities exchanges, new financial instruments, and experience in commercial risk assessment); and the growth of mutual and pension funds. The latter are a macroeconomic advantage if they add to overall savings levels and provide a vehicle for U.S. penetration into overseas equity and finance markets but a microeconomic disadvantage if the individual investor is not aware of the risks involved. *The United States's comparative disadvantages* in financial services are the low saving rate and the vulnerability of its information system, such as single-point (e.g., clearinghouse) operations as well as broader system characteristics. Our assessment showed the U.S. regulatory burden to be on balance neutral in comparison with that of other nations. That is, perceived domestic disadvantages in stricter regulation in disclosure and accounting standards are offset by the positive attitudes of overseas investors and general U.S. attitudes toward risk and business (e.g., U.S. versus Japanese handling of bad loans crises).

Based on our assessment, we make the following policy recommendations.

All levels of U.S. government should follow sound fiscal and monetary policy (including reducing the deficit, encouraging higher personal saving, and maintaining a favorable environment and infrastructure). The United States's low personal saving rate is reducing productivity and competitiveness by restricting the capital available for financing the construction of plants and the creation of jobs. In the next century higher living standards, national security, and U.S. economic preeminence will depend on productivity-boosting investments that start today. Sound public policy is crucial.

"It's time to face up to the fact that trust-fund accounting is a hoax, that Social Security is in fact a pay-as-you-go system. Payroll taxes go

directly to today's beneficiaries; benefits come directly from today's workers" (Peterson, 1996, 61).

Tax breaks to encourage longer-term investment horizons, research and development, and the transforming of basic technology into market products are examples of strategies government could pursue.

The federal government should continue to champion central bank cooperation, multilateral development bank efforts, and global deregulation of financial services. Keeping central banks focused on common policies for economic growth and price stability helps to provide a favorable environment for trade and investment. Multilateral development banks assist U.S. foreign policy aims by encouraging the spread of market-based economies. Continued global deregulation will allow U.S. financial services into new markets and expand their share in existing markets.

In summary, the U.S. financial services industry is the world leader that sets the standard for others. U.S. accounting principles, standards for information disclosure, venture capital formation, and risk assessment methodologies are key to this current position. Continuing ingenuity and effort will be needed to keep the United States out in front.

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HEALTH CARE INDUSTRY STUDY REPORT 1996

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ABSTRACT

Health care, the United Status's largest industry, continues to undergo dramatic changes as the government, business, and internal influences attempt to arrest its historically dramatic rate of cost increases. Notwithstanding those efforts, there remains a continuing challenge to balance lowered costs with high quality and increased access to care. This report summarizes the contemporary state of the health care industry. Its ability to effectively respond to change will ultimately affect the morale and national will of the nation's most important resource, the American people.

INTRODUCTION

The U.S. health care industry is a trillion-dollar enterprise. It is the nation's largest single business, consuming almost one-sixth of the U.S. gross domestic product (GDP), or about $4,000 per person (Califano, 1994). It employs approximately 9 million people, including over 600,000 physicians, 150,000 dentists, and 2 million nurses (Silver, 1995). Each of the industry's three complex sectors--health services, pharmaceuticals, and medical equipment and supplies--is undergoing dramatic change as the industry struggles to deliver health care in the face of four conflicting demands: high quality, low cost, increased access, and the preservation of patient choice. To satisfy these demands, managed care with a capitation payment approach to the delivery of care has emerged as the predominant force in the health care marketplace. Its effect has pervaded all sectors of the industry. In examining the health care industry, this report defines each sector, reviews its current conditions and challenges, and offers an outlook and roles for the government. The industry's ability to effectively deliver quality health care in the future will affect all Americans, directly or indirectly, as the nation continues to pursue an improved standard of living. Indeed, the industry's long-term viability will continue to affect national security by ultimately determining the quality of life for the human resources component of the national power equation.

HEALTH SERVICES SECTOR

The Health Services Sector Defined

This sector, the largest in the health care industry, consists of four components, each differentiated by the setting in which care is provided.

Hospitals. Modern hospitals generally have three major functions: patient care, medical education, research, or a combination. They are categorized by their type of care (general or specialized), function (e.g., teaching hospital), or size (community hospital or medical center). The trend is toward more academic medical centers, more ambulatory surgery, and fewer community hospitals (down 17 percent since 1981). Today, there are approximately 6,500 hospitals in the United States with a total of about 1.2 million beds (Carlstorm, 1994).

Provider practices. Approximately 200,000 private medical offices and clinics, about 75 percent of which are primary care practices (internal medicine, family practice, obstetrics, and pediatrics), employ about 1.5 million people. Solo practice is declining primarily as a result of the large debt physicians incur in medical school and the burden of malpractice insurance costs. Most physicians are in salaried staff positions, group practices, or corporate-sponsored medical care firms.

Nursing homes. Nursing homes are long-term care facilities used primarily for the elderly and those who are unable to care for themselves. About 23,000 such facilities in the United States have a patient population of about 1.3 million, 85 percent of whom are over the age of 65 (Silver, 1995). Nursing homes are classified as skilled nursing facilities, which provide around-the-clock supervision by a skilled nursing staff supervised by physicians; intermediate care facilities for patients who do not require a highly skilled medical staff; and custodial care facilities, which do not employ skilled personnel. The number of nursing homes has more than doubled since the 1960s because of the aging of the U.S. population and changing life-styles that separate the elderly from their families. There has been a recent increase in large nursing home chains that seek primarily to house the more profitable private-pay patients (Silver, 1995).

Home care. Home health services, the fastest-growing part of the industry (Freeman, 1995), consists of firms engaged in providing skilled nursing or medical care in the home under a physician's supervision.

Current Conditions

The health services sector is currently undergoing significant restructuring as it adjusts to a more market-driven approach to providing health care. Until recently, the economic structure of the industry shielded it from most of the laws of economic competition. A third party--usually an insurance company--typically paid most expenses, thereby shielding the consumer from the real cost of medical care. Even now, the average American still pays only 22 cents out of every dollar spent on health care (Carlstorm, 1994). Because consumers traditionally have had "imperfect knowledge" of the cost of medical care relative to its quality and benefit, they as well as physicians have had difficulty making rational health-related decisions based on economic considerations. However, under the guise of managed care, competition has been rapidly introduced into the health care system. The new focus on the relationship between cost and outcomes continues to bring dramatic changes to how and where the industry provides health services as well as to its financial structure.

Hospitals. By far, managed care is having the greatest impact on the $410-billion-a-year hospital industry. Cost pressures are forcing the closure of hundreds of inefficient facilities and reducing the number of beds in those hospitals that remain open. In the last 10 years, approximately 600 acute-care hospitals have closed, eliminating about 180,000 beds (Burns, 1995). Even after these reductions, as many as 447,000 excess beds remain--a surplus of almost 2,500 hospitals (West, 1994). Managed care reforms are reducing the average length of stay of the typical hospital patient and having a corresponding impact on industry profits. Analysts project declines of 26 percent in hospital admissions and 11 percent in average length of stay over the next four years (Voelker, 1995, 601). These declines could reduce hospital revenues by as much as 30 percent by the end of the decade (West, 1995a). The shrinking patient base has forced hospitals to lower costs aggressively by reducing the number of beds and staff and implementing horizontal and vertical integration strategies that lead to the more economical use of scarce medical resources. Larger hospitals are merging with smaller institutions,

and many are purchasing private physician practices and health maintenance organizations (HMOs) all in the name of market domination and financial survival.

Provider practices. Managed care is also having a profound impact on provider practices. Until recently, this segment, with approximately $210 billion in revenue, was a cottage industry of small, independent entrepreneurs. However, physicians are now joining with hospitals, other medical providers, and third-party payees in vertical alliances to provide the complete spectrum of patient care within a managed care environment. Currently, over 650 vertically integrated health care systems in the United States employ at least 100 physicians (Coddington, 1994). As managed care reforms increase the pressure to cut costs, the number of integrated health care systems will continue to grow. Additionally, hospitals and insurance companies are aggressively establishing cooperative agreements with group practices in order to form regional integrated health care systems.

Nursing homes. While the financial incentive to keep patients out of nursing homes grows under managed care, long-term institutional care for the elderly remains an important component of the services sector. Expenditures for nursing home care total over $70 billion annually, of which the government (mainly through Medicaid) finances about 60 percent, with the remainder being paid by patients or their families (Levit et al., 1994). Proposed reductions in the level of Medicaid reimbursements could hurt the nursing home industry financially.

Home health care. Closely related to the movement toward a more seamless health care system is the growing role of the $25 billion home health care market. There is an increasing reliance on less expensive home-delivered care for the elderly and chronically ill. About 15,000 home care agencies in the United States serve over 6 million patients (West, 1995, 5). The fastest growing segment in the health care industry, home health care has grown 30 percent over the past five years, primarily as a result of the aging of the U.S. population and financial pressures to treat patients outside of high-cost hospitals and nursing homes (West, 1995, 5).

Challenges

Socioethical and market-driven challenges face the health care industry in general and confront the health services sector specifically.

Socioethical challenges. Amazingly, over 41 million Americans do not have health insurance (McDonald, forthcoming). Ultimately, the nation must address how these citizens will receive care and who will pay for it. Perhaps even more important is the eventual aggregate effect of an aging population, continued technological advances, and rising expectations for access to quality and low-cost care--the so-called "iron triangle" dilemma facing health care. Elderly Americans (those over age 65) consume more than a third of U.S. health spending even though they constitute just 12 percent of the population. By 2030, this segment will make up 22 percent of all Americans (Rowley, 1996, 1). Without a change in how the nation takes care of its older population, Medicare costs could triple in 10 years to nearly $450 billion, helping to drive total U.S. health expenditures to nearly 30 percent of GDP by 2010 (Rowley, 1996, 3). Since the nation must accept the future graying of America and cannot--from a competitiveness standpoint--thwart advances in medical technology that increase longevity, the United States must address the attendant difficult ethical questions: How much care is enough? When, for whom, and under what conditions should the natural death process be allowed to occur in lieu of high-technology intervention?

Marketplace challenges. The services sector is undergoing a profound transformation as it adapts to a marketplace increasingly characterized by competition based on price and quality. It faces three key challenges: integrating comprehensive delivery of care, adopting outcomes management, and shifting to wellness and prevention.

1. Wellness and prevention: One of the key tenets in approaching the future of health care is to focus on "health" not "care" (Hancock and Garrett, 1995). Instead of just providing care, the U.S. health care system must change its focus from "repairing after the fact to a new paradigm that focuses on predicting, preventing and managing care" (Bezold, 1995a, 999). It is more cost effective to prevent disease and illness than to cure them (Bartling, 1995, 8). Lowering health care costs necessitates a shift in emphasis from acute and emergency care to wellness and

preventive medicine and entails a major change in the way health care providers interact with patients, since providers are traditionally trained to cure disease and illness, not to prevent them. Most wellness and prevention methods involve life-style choices over which providers exercise little direct control and the patient exerts almost total control. Therefore, patients can no longer be passive recipients of health care but must be active participants in maintaining their health (Goldstein, 1995, 62). Convincing patients to adopt and maintain healthy lifestyles requires education and incentives (Battagliola, 1995, 18). Such a major commitment of time and funds is problematic for an industry still charged with maintaining a world-class capability to cure and manage prevailing disease.

2. Integrated health care delivery: Stand-alone, independent health care provider organizations delivering a small array of health care services will find it increasingly difficult to compete in today's cost-containment environment as purchasers search for one-stop shopping for health care services (Lopez, 1995, 31). Providers that can deliver a full range of integrated health care services--primary care, acute and emergency care, rehabilitation services, long-term care, and home care--will have a competitive advantage. Achieving complete horizontal and vertical integration of all operations and structures--clinical, functional, organizational, and informational--is absolutely essential if a system is to be capable of delivering high-quality, low-cost, truly seamless health care (Goldstein, 1995, 60; Gillies et al., 1993, 468; Pointer, Alexander, and Zuckerman, 1995, 6-7). Coordinating business, management, and clinical practices among previously unrelated organizations represents a monumental challenge to the industry.

3. Outcomes management: The emphasis placed on high quality and low cost by health care purchasers produces the same forces in health care that drive innovation in other industries. Innovation requires a constant search for treatment protocols that produce the "best" outcomes in patients. Identifying the best outcomes presents several challenges. First, health care providers must define a best outcome and the aspects of patient health to measure in order to ascertain when it is achieved. Second, the industry must comprehensively analyze alternative treatment protocols to determine which ones produce the "best" outcomes since little analysis of this type has been accomplished to date (Mariner, 1994, 37-38). Finally,

if they are to maximize their competitive advantage, provider organizations must standardize patient care by establishing clinical practice guidelines based on those treatment protocols that produce the best patient outcomes (Shortell et al., 1993, 462). Outcomes management requires significant time and funding, but it carries with it many benefits, particularly for integrated health care delivery systems. It ensures that patients benefit from best clinical practices, minimizes the need for retreatment, provides for continuity of patient care, and reduces overhead costs for health care providers. These benefits translate into a competitive advantage for the provider and, it is hoped, lower costs for the consumer.

Outlook

As stated, the future of U.S. health care is more *health* and less *care*, more *self* and less *provider*, and more *here* and less *there*. The United States is embarking on a journey toward a future in which holistic health will become both a community- and a self-initiated norm. "Healthcare in America must go through a transformation in the early 21st century because the current system is unsustainable" (Rowley, 1996, 4). Perhaps a holistic approach to health improvement centered on prevention and expanded treatment approaches (e.g., chiropractic, acupuncture) can make up the shortfalls in the current U.S. civilian and military systems. Such "simple" foci as life-style changes offer tremendous payoffs. A former U.S. surgeon general has stated that variation in disease can be attributed to behavior 50 percent of the time, to environment 20 percent of the time, to genetic composition 20 percent of the time, and to medical care the remaining 10 percent of the time (Bezold, 1995b, 32). Currently, 96 percent of U.S. health care resources are spent on curing diseases or other existing problems, leaving only 4 percent for prevention (Olsen, 1995).

Civilian health services. Civilian health care organizations continue to reorganize, improve efficiency and quality, and fight for their very survival. "From 1987 to 1990 the number of hospitals owned, leased, sponsored, or managed by healthcare systems increased 13% to 2,567, accounting for 53% of all acute-care hospitals" (Rowley, 1996, 5). However, the 900,000 hospital beds in 1989 will probably fall to 300,000 beds in 2010 (Bezold and Mayer, forthcoming). Cuts in bed capacity and in the time patients spend in the hospital could reduce hospital revenues by as much as 30 percent by the end of the decade (West, 1995b, 9-10).

Furthermore, nearly 70 percent of respondents to a Health Research and Development Institute survey of over 2,000 hospitals stated that 20-40 percent of their total revenue comes from outpatient, not inpatient, care (Burns, 1995). The aim is clearly less expensive, outpatient care.

Military health services. With the "right-sizing" of the Department of Defense (DoD) came the need to reevaluate the philosophy of military health care. Reemphasizing its primary mission--readiness of the operating forces--military health care has redefined itself collectively as the Military Health Services System (MHSS). "MHSS is positioned to be the benchmark health care delivery system of the 21st Century, emphasizing readiness, health promotion, and managed care for all . . . entitled to care" (West, n.d.). Future decisions on resources and directions derived from this project are expected to position the DoD to provide optimal and efficient health care in the coming century. The formation of the MHSS may be a critical first step toward horizontal integration of service medical departments.

TRACER: The DOD's TRACER, which introduces the managed care approach into the military health care system, has given rise to complaints about the exclusion of Medicare-eligible retirees and about enrollment and per-visit fees. While very modest copayments may eventually become more acceptable, the more contentious issue is the widely held perception that the DoD intends to renege on a commitment to provide retirees care for life. Medicare "subvention"--reimbursement to DoD facilities for the costs of caring for Medicare-eligible retirees--would enable the DoD to continue to provide care to these loyal veterans. However, subvention requires congressional action, which has not yet been forthcoming. Hope on this issue still exists in the form of a provision in the 1996 Defense Authorization Bill expressing the "sense of Congress" that military facilities should be reimbursed for care to Medicare-eligible patients. Acknowledging that it is cheaper to provide such care in military facilities, the provision recommends that funds for such reimbursement be included in the FY 1997 budget (West, 1996). Medicare subvention merits continued pursuit to sustain the long-term cohesion of the military community. But because additional DoD cuts (including cuts in medical resources) are nearly certain, TRACER is not enough. While TRACER will place most service members and beneficiaries into some type of managed care setting, there is more to optimal health than managing

access and cost. The foregoing discussions on wellness and outcomes management must apply to the DoD as well.

Government Goals and Role

The government's interest in quality, cost, and access to care is paramount because health care spending consumes 14 percent of GDP. By 2000 nearly 19 percent of U.S. GDP will go toward health care alone (West, 1993). The federal government funds care for a substantial portion of society: the elderly, the poor, veterans, and U.S. military personnel. For reasons of policy and values, the United States remains firmly committed to guaranteeing affordable health insurance for all Americans.

Legislative actions. With the defeat of the president's Health Security Act of 1993, the governmental impetus for health care reform has moved to Congress, and reform bills continue to surface. On April 23, 1996, the Senate unanimously passed the bipartisan Health Insurance Reform Act of 1996, which was intended to provide greater health security for millions of families by reforming health insurance provisions. While this legislation contains several contentious issues that must be worked out in a House-Senate conference committee, if it prevails, (1) individuals will find it easier to retain their health care coverage as they change jobs, (2)insurance companies will be restricted in excluding coverage for preexisting medical conditions, and (3) it will be easier for small employers and individuals to band together to purchase insurance. The recently passed H.R. 3103, also intended to improve the portability of insurance, promotes the use of medical savings accounts, improves access to long-term care facilities, and limits malpractice liability. Whether the bill prevails--given the different philosophies of U.S. political parties and the exigencies of election-year politics--also remains to be seen. Nevertheless, there seems to be bipartisan consensus on the need for health care reform even if reaching agreement on methods and approaches remains difficult.

Medicare. Spending on Medicare, Medicaid, and other government health programs will rise from 3.3 percent to 11 percent of GDP by 2030 unless policy and programs change dramatically. The problem is how to reshape the current patchwork of regulations, payment systems, and conflicting incentives into a workable system without inflicting financial chaos on

providers and beneficiaries (Clarke, 1995). Medicare provides health insurance for most people aged 65 years and over and certain other disabled individuals; however, its funding is already severely out of balance. Medicare hospital insurance outlays now exceed its tax revenues, and predictions are that at the current rate of use the United States will deplete the Medicare trust fund by 2001. Home care, like other alternate-site approaches, has come under increased scrutiny as the government looks for ways to reduce payments to fraudulent providers. This scrutiny must be judicious and not disregard the lower cost of nonhospital care.

Domestic emergency response. In addition to the challenges of health care reform, the government is responsible for responding to civil emergencies and disasters. Its emergency response structure includes a consortium of 27 federal agencies, including the Department of Health and Human Services (DHHS), which is responsible for Emergency Support Function #8 (ESF-8), Health and Medical Services, under the Federal Response Plan. The Federal Emergency Management Agency (FEMA), as lead agency for the plan, has a strategy that addresses the need for surge and mobilization of health care during civil crises. The U.S. Public Health Service's National Disaster Medical System (NDMS) plays a key role.

Recommendations for government. The government should

1. Continue to pursue national health care reform as a priority, including initiatives that address health care access, coverage, cost containment, and quality assurance.

2. Reassess and change antitrust laws that might thwart horizontal integration (and its attendant efficiencies) within the health care industry.

3. Reform Medicare to include increased consumer choice and cost-conscious decision making for the elderly; incentives for accessible, high-quality, patient-oriented care; and innovative, cost-reducing delivery systems from the private sector that lay the groundwork for a fiscally solvent Medicare program.

4. Facilitate partnerships between federal and state governments on health care reform initiatives.

5. Promote more effective partnerships within the FEMA consortium and periodically exercise a coordinated government response for ESF-8 actions.

6. Ensure that wellness and outcomes management practices are incorporated into TRACER and given heavy emphasis in the MHSS 2020 Project.

7. Enact Medicare subvention to keep the faith with a loyal veteran population--if Medicare is to pay for their care, it makes good business sense to pay for it in DoD facilities, which provide care substantially more cheaply than civilian counterparts do.

8. Charge the DOD's MHSS with examining the integration of health care in the services. (Three separate service medical departments may be providing duplicative services in many geographic areas and conducting research and development [R&D] under redundant commands.)

9. Examine where heath services and functions can be consolidated throughout the government; the civilian sector's lesson in horizontal integration and consolidation should be instructive in this regard.

PHARMACEUTICALS SECTOR

The Pharmaceuticals Sector Defined

This dynamic, high-technology, and high-risk U.S. industry sector pursues the mission of discovering and developing new medicines or vaccines for the prevention, treatment, or cure of diseases. Currently the world's leader in the discovery and development of new medicines, the sector is highly dependent on R&D and must commit substantial resources to it early to attain acceptable long-term returns on investment. The sector is in a revolutionary transition period. Dramatic changes such as mega-mergers of large corporations will likely continue, and analysts predict that the number of drug companies could be halved within five years.

Current Conditions

The pharmaceuticals sector has also been influenced by managed care; however, it has still been able to sustain growth. Many areas of the sector warrant review.

Sales. The pharmaceuticals sector continues to grow. It has experienced significant cost efficiencies from major reorganizations and mergers, changes in Food and Drug Administration (FDA) regulations, and the adoption of the 1994 General Agreement on Tariffs and Trade (GATT), which extended the lives of many drugs. Also a factor in its growth is the demographic shift toward a more elderly population. However, the pace of annual sales growth is moderating; sales increased less than 5 percent in 1994 versus 11 percent in the previous decade. This moderation is attributable to the decline in the fee-for-service patients and political attention to lowering costs. Pharmaceutical revenues for 1995 increased just 5 percent, but projections are that sales will increase approximately 10 percent to almost $97 billion in 1996. The generic drug market is expected to explode commencing this year as over 51 prescription drug patents expire. By 2000, over one-third of the 300 best-selling brand-name drugs will probably be available in generic form. The number of prescription drugs being converted to over-the-counter (OTC) medications is also on the rise. OTC drug treatment is becoming the preferred way to treat conditions once treatable only through inpatient or outpatient hospital care. Sales of nonprescription medications, a $14 billion market in 1994, are projected to double by 2010.

Research and development. Research continues to be heavily endowed by the sector; investment in research is expected to reach almost $16 billion in 1996, representing almost one-fifth of anticipated sales. The average cost of a successful R&D project is almost $360 million over 12 years, but only 3 of every 10 new medicines put on pharmacy shelves in 1970 earned enough to repay manufacturers' R&D costs. Hence R&D investment is a fundamental but costly and risky undertaking that companies must pursue if they are to continue to compete in this critical industry sector.

International market and competitiveness. The European Community (EC), the largest importer of U.S. pharmaceuticals, accounts for 50

percent of U.S. exports. While Russia and the other members of the Commonwealth of Independent States are new potential markets for U.S. sales, there are many inhibitors, such as registration, testing, and license regulations. The EC and Japan are enforcing cost-containment programs in their countries--the EC in the form of reference prices and direct government price controls, and Japan in the form of automatic price reductions at various intervals in a product's life.

This sector is one of the few high-technology industries in which the United States still leads the world. U.S. drug firms generated a substantial excess of exports over imports in 1994. Despite international trade restrictions, U.S. companies remain strong competitors; sales account for over one-third of the $225 billion world pharmaceuticals market.

Productivity trends. Many U.S. companies are improving their productivity by reaping material cost efficiencies from major mergers. Others are benefiting from corporate realignment and restructuring. Reportedly, 18 leading drug makers pared some 38,000 jobs from their payrolls in 1993 and 1994. Nevertheless, the pharmaceuticals sector's manufacturing base, both in the United States and abroad, continues to exceed present requirements. Close to half of its capacity is believed to be idle. Further cutbacks in R&D and general administrative costs are expected to make firms more productive and competitive.

Challenges

The pharmaceuticals sector will face several challenges to its future. The most pressing is economically driven: firms must balance the continuing pressure to contain costs with the ability to generate funds for R&D in order to produce high-quality products, which requires innovation and continual appraisal of efficiencies. As Americans age and health care remains focused on managed care, the pharmaceuticals sector will have to make some difficult choices. Managed care, accounting for 50 percent of the pharmaceuticals market, is extremely price conscious, which will drive the cost of drugs down. Although drug-price inflation was curbed for a short period, it is once again creeping up. The FDA, negatively perceived by most domestic drug firms, remains cautious and conservative. However, because of increased pressure, it has improved the new drug review and approval process by reducing the median review time from 23

months to 19 months. However, the lengthy and complicated process still needs to be made more efficient. In addition, environmental issues will continue to challenge firms as new air emission standards and toxic pollution rules are enforced.

Outlook

Following a rough period of about two years, the short-term outlook for the U.S. pharmaceuticals industry is positive. However, the road ahead is not without problems.

Sector growth. Although the sector is not likely to return to double-digit growth levels anytime soon, the pace will improve steadily in 1996 and the ensuing years as a result of improving price trends, firmer drug markets overseas, and cost benefits from restructuring and cost-containment measures undertaken by leading firms. For the longer term, prospects for growth are mixed. On the positive side, the pharmaceuticals sector remains recession resistant. It continues to benefit from demographic shifts, particularly growth in the elderly population, which tends to use more prescription drugs. Finally, recognition that pharmaceuticals are more cost effective than hospital-based therapies should boost growth. On the negative side, the sector will continue to face considerable pressure from managed care organizations to control prices, the increased use of generic and OTC drugs, weak foreign economies, and uncertain prospects for health care reform. The overall outlook for this sector depends on its level of R&D, expansion of international markets, and, of course, the outcome of U.S. health care reform. Therefore, firms must pursue four strategies to remain global leaders:

1. Continue to restructure to achieve cost savings through synergy in new product development, manufacturing, marketing, and R&D.

2. Increase global markets and overcome price controls, illegal use of patents and copyrights, and foreign regulations.

3. Focus on disease management so that products become an integral part of the buyer's patient care plan.

4. Use risk-sharing programs with managed care partners so that both are equally at risk for the success or failure of products.

National security requirements. DoD peacetime requirements make up less than 5 percent of the total market for pharmaceuticals. The sector could support national security surge requirements during a major mobilization with little difficulty through stock on hand and minor production surges. However, current stocks of vaccines, antibiotics, and autoinjectors are inadequate for the threat of multiple biological warfare agents that the United States faces.

Government Goals and Role

The federal government's role in the pharmaceuticals sector should center on achieving the following goals:

1. Reform and streamline the FDA drug approval process consistent with public health requirements; form a partnership with the industry.

2. Support high-priority R&D efforts at academic research centers.

3. Broaden the effect of price competition by allowing advertising.

4. In association with the pharmaceuticals sector, develop agents for prophylactic and post-exposure use against chemical and biological threats.

MEDICAL EQUIPMENT AND SUPPLIES SECTOR

The Medical Equipment and Supplies Sector Defined

The technologically diverse medical equipment and supplies sector is divided into five components: surgical and medical instruments, surgical supplies and appliances, dental equipment and supplies, X-ray apparatuses and tubes, and electromedical equipment. It encompasses equipment and supplies ranging from heart pacemakers and implants to bedpans and bandages. The sector is highly dependent on R&D and has strong linkages with other high-technology industries such as semiconductors, computerized imaging, electronic data transfer,

superconductivity, artificial intelligence, virtual reality, and advanced materials. Approximately 10,000 U.S. firms are involved in manufacturing medical devices, and about three-quarters have fewer than 50 employees. The sector averages employment growth of just over 3 percent; current employment is estimated at over 287,000.

Current Conditions

Thirteen of the world's 20 largest medical technology firms are based in the United States. These firms accounted for nearly $50 billion in sales in 1992, or over half of the global sales of medical equipment and supplies. International demand for U.S. products increased approximately 10 percent to $10 billion in 1995. The sector has consistently produced trade surpluses: $1.6 billion in 1989, $4.5 billion in 1995, and estimated at $5 billion in 1996. In 1993, the industry spent 7 percent of sales on R&D.

U.S. firms are most competitive in areas of medical implants, diagnostic imaging, and patient monitoring. Although initially costly, compliance with International Standards Organization (ISO) 9000 Series standards may result in the most efficient access to the EC market. Trade tariffs cost the industry approximately $6 billion in delays. In the development of information technology, a significant part of this sector, the military leads in R&D and the application of information systems. The advent of telemedicine services linking medical teams throughout the world to U.S.-based hospitals has resulted in fewer medical evacuations, decreased care time by 28 percent, decreased costs, and decreased the medical force footprint overseas. Through 1996, the sector expects a 10 percent growth rate and worldwide sales of medical information systems exceeding $800 million.

Challenges

FDA regulations have caused many U.S. firms to relocate their R&D and production to Japan and Germany, where they benefit from lower production costs, more timely development, and proximity to foreign markets. Overseas investment by U.S. medical device firms increased threefold to more than $1 billion from 1989 to 1992.

European and Asian firms enjoy foreign-government subsidies and preferential export credits; those in Asia are increasing their ability to produce high-technology medical equipment and are moving into markets to compete with U.S. firms. As a result, the share of the $93 billion global market held by U.S. medical equipment and supplies decreased from over half to just 49 percent in 1995.

Because of costly product liability suits, suppliers of crucial materials and components have restricted their products' use, especially in implants and invasive procedures, a development that threatens future technological innovations. Prime-vendor contracts have decreased the cost of medical equipment and supply for military treatment facilities during peacetime, but the shift to just-in-time production and delivery raises a serious concern about the potential for mobilization, despite industry representatives' claims that they can meet surge requirements.

Outlook

Regulation, the international market, and mobilization surge potential are key areas to watch over the next few years. While not the largest part of the health care industry, the medical equipment and supplies sector will ultimately provide the tools with which low-cost and high-quality health care is provided.

Regulation. The FDA currently regulates about 1,800 types of medical devices and estimates that there will be over 100,000 more new and improved devices by 2000. According to several firms, "user fees" paid to the FDA have not substantially shortened its review and approval process. Although the FDA has decreased its average review time for medical devices similar to existing devices by one-fourth, most firms are adopting the "Europe First" production strategy.

The recent U.S.-Japan Framework Agreement calls for an increase in Japan's purchases of medical devices. A trade promotion group is working to remove regulations to increase exports, and the FDA's Global Harmonization Task Force should decrease duplication and disparity in regulations in the United States, the EC, Canada, and Japan.

International market. The increases in per capita income and health care spending expected in Argentina, the Association of Southeast Asian Nations, Brazil, Chile, China, Hong Kong, Taiwan, India, Mexico, Poland, South Africa, South Korea, and Turkey will likely translate into heightened international demand for and exports of U.S. medical devices. Development of integrated health care systems, networked to interstate telemedicine services, can increase access to care and decrease costs for the consumer. Also, the United Status's significant competitive advantage in advanced medical research and specialty clinical practice will enhance its opportunities to sell advanced information systems for worldwide telemedicine consultative services.

Mobilization/surge potential. The military's Global Medical Logistics Operations Center, tasked to identify and set priorities for surge requirements, will ensure support for U.S. first-deployed units while theoretically allowing the production base time to meet full surge requirements. Industry's position is that it can meet U.S. requirements, but without periodic exercises and notional supplier participation, there is no way to validate this claim.

Government Goals and Role

The government can have a substantial effect on the future ability of the medical supplies and equipment sector to provide the materiel support necessary to sustain U.S. leadership in health care. Four recommendations follow.

1. Privatize product review for Class 1 and Class 2 devices, leaving only the more sophisticated review requirements within the realm of the federal government; motivated by competition, the industry can police itself.

2. Encourage and offer incentives to firms that comply with ISO 9000 Series standards in the interest of U.S. global competitiveness and increased access to overseas markets.

3. Subsidize the development of dedicated national and international telemedicine information systems to enhance military medical readiness and seize market opportunities for U.S. firms in global consultation services.

4. Institute tort reform for product liability to decrease costs to companies and increase the supply of crucial products.

CONCLUSIONS

Health care is an enormous and complex industry that will continue to undergo dramatic changes in the next several years. Managed care will fulfill its mandate to contain costs; yet, as it matures, it will shift its focus from low cost and access to quality of care and the many attendant ethical issues. Horizontal integration and consolidation of health care organizations will continue to promote efficiencies, but the government needs to apply the same strategy within its construct to render beneficiary and entitlement health care efficiently.

Legislative actions are needed to lift antitrust prohibitions that might thwart private sector reorganization for efficiency; transform the FDA's relationship with industry into a partnership; keep the faith with the military and veteran community to which the government is indebted for its very existence; guarantee the solvency of the Medicare Trust Fund; and protect the U.S. populace as the landscape of health care continues its dramatic change.

The government must also be more proactive in the development of pharmaceuticals for chemical and biological defense preparedness. Finally, the government, business, and the people must adopt a new paradigm emphasizing wellness and prevention as the principal modalities of health care.

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INFORMATION INDUSTRY STUDY REPORT 1996

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ABSTRACT

The dynamic track of information technology features nonstop change; competition; convergence; shifting, expanding, opened, and closed markets; and domestic and international alliances. Rarely in history has a single technological development experienced the phenomenal rate of growth that the information technology industry has. Societies around the globe rely increasingly on advanced telecommunications, computer, and other automated information systems in everyday life. Without question, information technology is a force for change--social, political, and economic.

INTRODUCTION

Just as past ages were called bronze or iron after the dominant technology of the times, so should this age be characterized as the information age. For unquestionably the computer and telecommunications information explosions have dominated technology and thereby made irreversible changes in the way people live and work (Lebow, 1995, xiii). The convergence of technologies in computers and telecommunications is changing the world as radically as the industrial revolution did over 200 years ago. The pace of commerce is accelerating exponentially because information technology is transforming the capability of industry and government to conduct business and the means by which they do so.

The information industry, built on a strong base of leading-edge technology, is rapidly expanding, chaotic, and ever-changing; the slightest misstep or delay in bringing a product to market can mean disaster for even the best companies. Ironically, this industry's technology and infrastructure enable all other industries to innovate and expand. Unquestionably, the information industry is a fundamental strategic industry for the United States.

Three pillars will take the information industry into the future: content, infrastructure and services. The content pillar, including voice telephony, video on demand, and multimedia, is the impetus for growth and maturity. With technology advancing rapidly, demands on the industry are limited only by the imagination and expectations of all other industries. The latter

two pillars make up what is referred to as the information industry: a delivery system for content generated elsewhere. Clearly, a modern and improving infrastructure is required to provide industries with a competitive advantage in today's global environment. Likewise, the service sector allows individuals and businesses to choose from numerous combinations of local, cellular, and long-distance telephone service providers.

Access to information and an understanding of how to use new technologies not only are essential for economic success and national security but are basic abilities people need to function in the evolving global society. In short, today's world depends on managing the technology, managing the use of the technology, and managing with technology.

THE INFORMATION INDUSTRY DEFINED

Through the early 1980s, the term *computer* covered just about the entire gamut of information processing. Today, *information technology* is the generally accepted umbrella term for a rapidly expanding range of equipment, applications, services, and basic technologies that fall into three primary categories. The first is computers, which are classified as mainframes, the largest ones; minicomputers, the intermediate size; microcomputers, tagged as the smallest; self-contained portable or personal computers (PCs); and supercomputers, ultra-high-speed processors used primarily for scientific and engineering applications. The second category is telecommunications, or the electronic movement of information via telephone services, video conferencing, voice and video e-mail, and digital cellular communications. Multimedia data, the third category, is a catchall term for the transmission and manipulation of any form of information. It is designed to combine video, animation, still pictures, voice, music, graphics, and text into a single system (Keen, 1995, 165).

Through its global operations, the U.S. computer equipment industry controls more than 75 percent of the world computer market. Computer prices have been continuously declining, but the steadily rising performance and increasingly sophisticated uses of computers have

stimulated domestic sales and exports. As a result of the ever-accelerating tempo of technical change, product research and development costs have increased significantly. The industry's operations have become more global, and companies have formed domestic and foreign alliances to ensure that the lowest cost components and latest technology are available.

Telecommunication services include communication service for local-area, long-distance, international, cellular and mobile radio, satellite, and data communications as well as networking services. Over 2,000 companies, employing approximately 900,000 people and earning revenues estimated at $200 billion for 1995, provide telecommunication services. The Telecommunications Act of 1996 will make sweeping changes in this sector by encouraging competition and reducing regulations. It will allow long-distance providers, local phone services, cable companies and Internet companies, within certain limits, to enter each other's previously protected markets. Open markets should induce competition, improve service, and reduce costs to the customer.

Multimedia applications are the result of the convergence of audio, video, graphics, and text processing. Unlike traditional computer software, which consists of text, graphics, and high-pitched beeps as the sole audio effects, multimedia applications come with full-motion video, good-quality voices and music, and high-resolution graphics and text. Multimedia is a mass commodity largely because of the development of the compact disc as a medium for storing data. It is becoming a basic component of desktop computers, and the working world is starting to take advantage of digitized audio and video communication across networks or high-speed phone lines. In the workplace multimedia communications take several basic forms: videoconferencing, electronic document sharing, video- and voice-annotated electronic mail, and computer-based training (Baran, 1995, 203). Other areas, such as education, health care, and the sciences, are moving fast to exploit multimedia services.

CURRENT CONDITIONS

The information industry is one of the United States's most dynamic, growth-oriented markets. In general, predictions for information

technology trends tend to favor a swing upward at an exponential rate. Historically, once an innovation reaches a critical mass of users, it grows at a rate of 10-20 percent a year. The best example of this phenomenal growth is Moore's Law. In 1965 Gordon Moore, the cofounder of Intel, predicted that the capacity of a computer chip would double every year based on the price-to-performance ratio. To this day his predictions have held up, and the average rate of increase is a doubling every 18 months (Gates, 1995, 31). Also, in 1995 several telecommunications technologies were in the take-off stage: commodities such as cellular communications and advanced fast packet-switching techniques grew in volume between 40 and 60 percent. Today, multimedia is the area to watch. It may need a longer initiation phase, but once it starts a very fast take-off is expected.

In today's global economy the U.S. information industry has concerns about *subsidies, quotas, trade barriers,* and *level playing fields.* The controversial questions no longer relate to whether foreign intervention in high-technology industries exists but instead are whether such intervention influences competitive outcomes to the disadvantage of U.S. producers, whether structural differences among nations tilt the playing field, and how much the United States is harmed economically by such practices (Tyson, 1992, 9) Such issues and concerns are being addressed by several international organizations, including the General Agreement on Tariffs and Trade, the North American Free Trade Agreement (NAFTA), and the World Trade Organization (WTO). Multilateral efforts now underway to realize the maximum potential of a global information infrastructure (GII) include negotiations based on worldwide liberalization of basic telecommunications services that fall under the umbrella of the WTO. The United States is also working on other GII-related issues in other multilateral fora, such as the Organization for Economic Cooperation and Development and the World Intellectual Property Organization (LeBel, 1996, 49).

Many foreign governments provide varying levels of support for home-based companies, which creates an uncertain advantage for U.S. companies. The playing field is also tilted by differing concepts of ethical behavior. China and other emerging nations exacerbate this competitive uncertainty through various actions that cause U.S. companies to take up-front losses and assume higher-than-normal risks in order to open up the

market in anticipation of future positive returns. For example, China plays one company off against another by conditioning a contract award on a slim or nonexistent profit or the acceptance of a net loss in order to get a foot in the door of an expanding market. The Chinese recognize that in the long term a foothold in the market could be very lucrative for the winner and maximize the fact that they are negotiating from a position of strength.

Trends in productivity indicate that the U.S. information industry will continue to be among the fastest-growing sectors of the economy. The government and other industries depend on the industry to develop innovative solutions to problems and to continue to increase productivity, efficiency, competitiveness, and employment in the United States. For example, the telecommunications industry's productivity rate is growing because of the insertion of rapidly advancing technology into all segments of the business, on both the software and the hardware sides. Intelligence being installed throughout networks is transforming them from dumb carrier pipes to multimedia communications exchange servers and allows multimedia telephone calls with voice, data, image, and video to be incorporated into office local-area networks (LANs) and wide-area networks.

Clearly, the information technology industry is *competitive in the international arena.* All sectors of the information industry have experienced significant growth. Hardware, semiconductors, software, and services remain some of the healthiest segments of the U.S. economy. Projections are for growth of 10 percent or more for each sector through 2000. New applications such as image processing should spur sales of large computers to manage the growing mass of data on PCs. From the perspective of international competitiveness, the United States stands at the top of the global computer industry. In 1993, all but 2 of the top 10 PC companies worldwide were American. In each sector the United States controlled more than 75 percent of the world market. However, although the United States has remained the top exporter of computers, the U.S. computer industry has lost ground to the Japanese industry since the early 1980s. Over the past 10 years Japanese computer exports have risen 21 percent annually. In any case, while Japanese computer exports are a concern, the United States is the world leader in the provision and export

of information services, and U.S. firms continue to dominate the market, both in terms of number of companies and revenues (Department of Commerce, 1994, 27-1).

Attractive, long-run marketing opportunities in equipment manufacturing and service offerings exist in all regions of the world. Developed nations will get enhanced services; developing nations will see basic network building along with cellular ones. With the connecting of the telephone and the computer, the world telecommunications sector continues to be one of the largest and fastest-growing sectors of the global economy.

There is no question as to the *profitability of the information industry*. The U.S. information industry has always had a positive balance of payments (Department of Commerce, 1994, 27-5). In 1994, the 10 largest telecommunications giants made bigger profits than the 25 largest commercial banks. Additionally, for the past several years 6 of the 10 companies with the largest worldwide software revenues were U.S. companies. Estimates put the global market for telecommunication services alone at $750 billion and growing fast. However, the profit growth will be tempered over the next few years by heavy capital investment as new and existing companies enter new ventures such as personal communications services, video on demand, and long-distance and local telephone markets.

Today, the *information technology industry affects every other industry;* it enables other industries. Information technology, the combination of computers, telecommunications, and information resources, fundamentally is about business making change an ally rather than a threat (Keen, 1995, ix).

One of the most exciting and enabling aspects of technology is the availability of the Internet, which is causing an explosion in both business and individual use of computers for communications and information transfer. PCs are now gateways to worldwide information repositories. Even though satellite television and radio allow people all over the globe to receive news and entertainment at any time, it is the Internet that allows people to exchange information and ideas in real time.

Notwithstanding the phenomenal rate of change in the industry and the excitement of the Internet, one single action has had the strongest impact on all sectors of the information industry: the passage of the Telecommunications Act of 1996. This law encourages competition and reduces regulations by eliminating regulatory carriers between long-distance providers, local phone services, cable companies, and electric utility providers and allowing firms to enter each other's previously protected markets, although with certain limitations. The end result should provide both business and private customers with one-stop shopping for all their information needs, whether voice, stereo sound, high-speed data processing, or full-screen interactive video on digital television. As well, the open market should induce competition, improve services, and reduce costs to consumers and businesses.

CHALLENGES

The numerous challenges facing the information industry must be resolved as the information age matures in the 21st century. It is imperative that U.S. and international governments understand that they must step up to the formidable task of industrial strategic planning. Critical issues include the industry's ability to respond to rapidly changing information needs and to develop appropriate technology and applications that will deliver services quickly and efficiently. Especially sensitive areas that pose major challenges are *education and training, infrastructure, intellectual property rights (IPR), security and privacy, universal access, standards, evolving technology, and the implementation of the 1996 Telecommunications Act.*

1. Information is a lucrative and desirable industry for the best and brightest people. The challenge is *educating and training* enough people to keep U.S. companies globally competitive. Employees in the information industry must accept change, work on small, integrated teams, and constantly learn new skills and technology. Many information industry companies have formed partnerships with state and local governments and educational institutions to produce future employees and to retrain current ones.

2. The major challenge for public and private sector customers will be to invest in the key *infrastructures*. They must make sure their investment delivers a return that is relevant and effective today and does not become obsolete tomorrow. Capital markets have responded well so far, but they will be challenged as more and more telecommunications stock offerings are brought to market to finance mergers, acquisitions, and foreign privatization. Subsequent to the privatization, large amounts of capital will be needed to finance the required upgrades to the infrastructure.

3. Overcoming the abuse of *IPRs* is another major challenge. One concern is how the United States can strengthen domestic copyright laws and international intellectual property treaties to prevent piracy and to protect the integrity of intellectual property. Vigorous protection of IPR, which apply to patents, copyrights, trademarks, and trade secrets, is critical to trade in the information industry. Although many countries have improved their IPR practices in recent years, it is estimated that piracy deprived the United States of about $13 billion in worldwide revenues in 1993.

4. Society relies increasingly on advanced telecommunications, computer, and other automated information systems in everyday life. In light of this dependence, a secure and highly efficient national information infrastructure (NII) that can ensure privacy is vital to the continued economic growth and national security of the United States. The most serious threat to the commercial, economic, and political *security and privacy* of the NII will come from information terrorists, from whom there is seemingly no sanctuary. Commercial organizations, especially those in telecommunications, finance, transportation, and power generation, offer choice targets, and unauthorized access to military networks is a major concern. The Department of Defense (DoD) is working on an offensive operation, referred to as *information warfare*, that targets an enemy's information-based systems. Likewise, the industry has developed *information assurance* to defend against intrusion into the content of their information systems. Computer crime is viewed as the fastest-growing component of global organized crime. Unfortunately, the extent of this crime is masked by nondisclosure from businesses that fear the exposure would lead to a loss of customers.

5. All citizens must be assured of *universal access* to telecommunications services. Some analysts fear that new classes of information haves and have-nots will emerge unless the United States extends today's policy to include the new technologies. The Communications Act of 1934 articulated a national goal of service at affordable prices; its replacement, the Telecommunications Act of 1996, falls short of assuring universal coverage by extending this goal to only some competitors. As technology evolves, the nation must reassess what basic service comprises and ensure that it is available at affordable prices.

6. *Standards* are the single most important element in integrating corporate information and communications (Keen, 1995, 251). The standard-setting process can be extraordinarily cumbersome and lengthy, as no single controlling force in the market determines universal standards. For example, nearly 50 committees and organizations are involved in setting standards for international telecommunications, resulting in a great deal of overlap and conflict. Resolving competing points of view and determining industry standards will remain a challenge. If too much time is spent developing the standard, the market moves on; if too little time, the product may have flaws that make it unacceptable or cumbersome to the consumer.

7. Technological advances in the information industry continue to support an increase in processor speed and a reduction in the size of computers. Developments like network computers will reduce the size of computers and the cost of owning them for businesses as well as individual users. The use of global networks, virtual reality, and nanotechnology will make it easier for consumers to communicate complex ideas and shapes globally at a fraction of the cost of conventional means.

8. The Telecommunications Act of 1996 is a notable achievement that improves the competitive situation of combinations of U.S. industry. However, a final challenge will be for the Federal Communications Commission to fulfill its congressional charter as the "honest broker" in developing and enforcing regulations for a comprehensive implementation of this law.

OUTLOOK

The U.S. information industry is able now and in the future to support *national security resource requirements*. Mobilization applies to the telecommunications industry in two basic contexts: the manufacture e of equipment and components for use by U.S. military forces and the provision of additional telecommunications capacity and services to support increased demands during crises and emergencies.

The challenge is to look at the mobilization of the telecommunications industry and the needs of industry and government in the light of changes in industry and in ways of thinking about mobilization. In essence, the *impediment to the industry's achieving a full-scale surge and mobilization potential* is the industry's leaders, who are not persuaded to make a commitment to mobilization or to spend money on it. However, this reluctance is not a reason for alarm. Immediate needs for national security can be satisfied by reallocating and adjusting priorities for existing services and capacity. Midterm requirements would exceed the current capability, thereby compelling the reallocation of resources already on hand or in the production pipeline. The long term could be difficult, as it would call for the rapid expansion of the production base under stressed conditions. A mobilization requirement would likely be very expensive, difficult, and time consuming (Garing, 1986, 163).

The *short-term outlook for the U.S. information industry* reflects a highly competitive industry poised to capture the lion's share of the exploding demand for information products and services. Globally, market liberalization is continuing to drive competition. For the remainder of the decade, the world market for telecommunications equipment and services is expected to grow 9.2 percent per year, compared to a 3.1 percent growth in world gross domestic product. Currently, the U.S. computer equipment industry controls more than 75 percent of the world market, and in 1994 the United States captured 46 percent of the world information service revenues.

Market shifts and expansions continually change the scope of the information industry. A major boost to U.S. exports will come from the rapidly expanding markets of Latin America and Asia (particularly India

and China). Many countries are deregulating and privatizing state-owned public telephone companies, which will give U.S. firms access to markets that have been closed or restricted. Advanced U.S. technology and efficiencies generated by years of domestic competition will give the U.S. firms a solid lead in capturing these new markets.

Additionally, new firms taking advantage of the opportunities created by the 1996 Telecommunications Act will enter the market. Currently a wave of mergers and alliances focusing on traditional telecommunications services is taking place in the United States and abroad as companies seek less expensive ways to exploit new technologies and market openings. Cable companies are entering the telephone business by using cable lines to provide access to homes. Under the new law, telephone companies can merge with cable companies and use existing lines in homes and business to deliver voice and data communications as well as entertainment packages. In the next few years a more concentrated industry will offer consumers fully bundled services that will include telephone; Internet; entertainment; home shopping; and financial, social, and governmental services. Dominant players will be supplemented by entrepreneurial companies filling niche markets or providing attractive services that will lead to flattened rates.

The Internet is an admirable example of the technical ingenuity and pioneering spirit of the computer science community. It offers tremendous profit potential and is therefore attracting cable and telephone companies as part of their overall scheme to provide bundled services. Telephone companies are concerned about their market share and competitive position, as it is assumed that the future use of the Internet will include voice and video-voice transmissions. At this point, the quality of voice transmission over the Internet requires substantial improvement; however, intense competition for access will be good for consumers, and rates should drop as the ranges of services increase. This could drive a restructuring of the telephone service pricing system from a charge-per-minute to a flat-rate basis.

Faster and cheaper technologies being produced will allow firms to expand their LAN technology to include intranet lines. A great enhancement to this process is the wireless LAN, and intelligence added to

the systems will enable multimedia telephone calls with voice, data, image, and video to be incorporated into office networks. The expense of having separate office telephone and computer networks will eventually be eliminated. However, neither customers nor providers will allow themselves to be too dependent on a single manufacturer's hardware. Instead, they will rely on the compatibility of network components, plug-and-play technology, or open-system architecture. Uniformity of industry standards, even in the face of intense competition, will be the key to the Internet and intranet.

On the other hand, the *long-term outlook,* perhaps to 2020, favors the development of other technologies, such as virtual reality, holography, nanotechnology, and artificial intelligence, that will enhance the services available through the network of networks. Further development of satellite technology will support high-definition television and video conferencing; however, most satellites will become obsolete after a few years and will need to be replaced continually. Increasingly, major bilateral and multilateral trade disputes may occur as firms battle to obtain licenses to launch new satellite clusters and gain market advantage.

In the long term the public network switching system, which is primarily designed to handle 64-kilobit voice channels, must be upgraded. A new system capable of handling 1.5 to 2 megabits per second will require higher-speed and wider-band video and data communications. Asynchronous transfer mode switching is believed to be the best solution to the problem, although its cost could delay fielding of upgrades for nearly 10 years. Revenues from this segment will increase as the new technology is deployed both domestically and abroad. The demand for wireless services has risen beyond all expectations. In the decade ahead, wireless networks will deliver personalized communications to people on the go and basic service to many who still lack telephones.

The *political and social implications* of the new technologies are substantial. Devices such as pocket-sized automatic translators will have a profound effect on geopolitics and social attitudes. On the mundane side, the improvements in technology will allow federal and state tax systems to move toward full-service automated tax filing. On the esoteric side, the global positioning system is revolutionizing major aspects of social and

commercial activity in sectors such as transportation, law enforcement, and emergency preparedness. The Internet offers the potential for political uses from campaigning to voting by computer. In some cases, the growth of the Internet even raises the question of whether the United States is moving away from a representative democratic society to one that is truly participatory primarily as a result of the advances in information technology.

Several issues outlined above will be the focus of public debate. Attempts to control content (e.g., pornography and violence) on the Internet have economical and societal implications. A delay in developing measures to protect intellectual property could retard the full exploitation of new technologies, while the lack of security on the airwaves leads to concerns that too many people may have access to one's personal information. Also, the potential for information terrorist attacks and computer crime is receiving close scrutiny from the government, the DoD, and private industries. Nevertheless, in the short and long term, the *information industry is postured to respond to the issues and challenges* of the 21st century. In fact, technological and legal measures designed to secure data, protect networks, aid law enforcement efforts, and help an industry ready to deal with the competitive and regulatory consequences of all these issues will steadily proliferate.

GOVERNMENT GOALS AND ROLE

The federal government has a crucial role in sustaining the U.S. lead in information technology, since the continued acceleration of technological change and the global recognition of the strategic value of these technologies mean that any nation can make bold advances if it makes wise investments. At stake is the technology that will determine the nation's ability to sustain economic well-being, to compete successfully in the global marketplace, and to enable affordable national security.

Drawing on more than 40 years of both federal and industrial investments in this technology, the U.S. government needs to build partnerships among business, labor, academia, and the public. Specific government goals should include the following.

Extending the universal service concept to ensure information resources are available to all at affordable prices. Because information means empowerment, the U.S. government must assure universal access to basic telecommunications services for all citizens. As a matter of fundamental fairness, this nation cannot accept a division between information haves and have-nots. Likewise, ensuring the privacy of information and the security of communications and networks is essential. Users must be certain that information transmitted through electronic means will go when and where it is intended to go. The government must work with industry to develop new technologies that protect privacy and must enable law enforcement agencies to continue to use court-authorized wiretaps to fight terrorism and organized crime. The U.S. government must strive to identify threats and vulnerabilities to criminal and terrorist activity. A priority should be to develop encryption hardware and software for this application.

Reversing the perception that the U.S. work force lacks the education and training to be world leaders in developing, manufacturing, and providing information services. The government should formulate a national policy that would consolidate the more than 150 government education and training programs, thereby eliminating redundancy and inefficiency. The money saved should be used to fund innovative approaches to education that fill the gap left at the end of traditional public education. The information industry needs an educationally sophisticated, though not college-educated, work force to remain globally competitive.

Developing standards for voice, video, data, and multi-media services that ensure interoperability and openness. The standards must be compatible with the large installed base of communications technologies, flexible, and adaptable enough to meet users' needs at affordable costs. Equally important is the avoidance of trade barriers raised by incompatible U.S. and foreign standards. The government can be a catalyst in this industry-driven process by participating more actively in domestic and international standards panels and committees with the goals of addressing strategic technical issues of interoperability and eliminating or reducing trade barriers.

Adopting export control policies and international trade rules that are favorable to information industries. U.S. firms must have an opportunity equal to that of international competitors to export telecommunications-related goods and services to potential overseas customers. If restrictions on products do not conflict with national security goals, the United States should remove the restrictions and permit U.S. manufacturers to enter new international markets.

Supporting the development of the NII/GII and protecting IPR. The government must balance the broad public interest in promoting the dissemination of information across the information superhighway with the need to ensure the integrity of IPR, whether the property is text, images, computer programs, databases, or video or multimedia formats. The government should aggressively pursue the strengthening of domestic copyright laws and international intellectual property treaties to prevent piracy and to protect the integrity of intellectual property. An efficient system should be developed to identify, license, and pay royalties for copyrighted products delivered and available over electronic information systems.

Promoting private industry investment in technological innovation and new applications of software. Government regulatory, antitrust, tax, and intellectual property policies all affect the level and timing of new offerings in services and equipment, including the technology base that generates innovations for the marketplace. The government should support research and technology development through partnerships.

Developing surge and mobilization policies to support national security resource requirements. The government must identify force requirements and capabilities in the arenas of information management and assurance. A first step would be to define what mobilization and surge in the information industry means. A starting definition could be "the process of marshaling the information and telecommunications resources needed to make the transition from a normal state to a state of readiness for a national emergency." Clearly the United States faces the prospect of warfare conducted outside the boundaries of traditional militaries. The future national security of the United States may depend on the nation's

ability to adequately plan, develop, and implement information assurance measures.

The U.S. government fashioned a revolutionary approach for acquiring information technology in the acquisition arena by repealing the Brooks Act of 1965 and replacing it with the Cohen Act in the 1996 Authorization Act. The cutting-edge management guidelines established by the Cohen Act directly empower executive agencies; ensure central coordination, which enhances efficiency; simplify competition requirements and commercial purchase processes, which should result in savings and improved product reliability; and decentralize budget and procurement efforts to provide more line responsibility and quicker response time between the need statement and the fielding of the system(s). As a result, the warfighter will have what is needed, when it is needed, and the taxpayer will have value added for each tax dollar.

In conclusion, the U.S. government must stay committed to the high-technology growth industries of the next century. It must continue a policy of aggressively seeking opportunities to minimize competition-stifling regulations and foster free markets at home and abroad. Clearly, NAFTA and the WTO are relevant to the expanding global competitiveness of the U.S. information industry. NAFTA goes a long way toward eliminating entry barriers within North America and requires the adoption of international telecommunications standards. Drawing on trade rules for telecommunications services developed in the Uruguay Round, WTO members are working to forge consensus on many issues critical to open markets. Expanding NAFTA south and opening additional markets through strong leadership in the WTO are appropriate and worthwhile government goals.

The principles and goals outlined in this report provide a blueprint for federal government action relative to the information technology industry. Pursuing these goals will ensure that the government constructively assists U.S. industry, labor, academia, and private citizens as they develop, deploy, and use the various information technologies.

CONCLUSIONS

Information systems permeate the lives of U.S. citizens in the current information age. They will define the 21st century and influence all the nation's activities. As is true of all major changes, the benefits of the information age will carry some costs. Dislocations in some business sectors will increase the need for further education and retraining. The availability of rather inexpensive communications and computing will alter the relationships of nations and of socioeconomic groups within nations. The power and versatility of digital technology will raise new concerns about privacy, commercial confidentiality, and national security. Moreover, equity issues will have to be addressed; the information society should serve all citizens, not just the technically sophisticated or economically privileged (Gates, 1995, 251). The challenge for leaders is to recognize the implications of change in this new environment and identify ways to make sense of its chaotic activity.

The information industry is an essential strategic element of national power. It underlies all other industries and provides the infrastructure that enables their success. The industry's potential benefits for the nation are staggering: full exploitation of information technologies will enable U.S. firms to compete successfully in the global economy, generate good jobs for the American people, and enhance the nation's economic growth. Of equal importance, the explosion in information technology promises to transform the lives of the American people. It can ameliorate the constraints of geography and economic status, and give all Americans a fair opportunity to go as far as their talents and ambitions will take them.

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LAND COMBAT SYSTEMS INDUSTRY STUDY REPORT 1996

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ABSTRACT

Land combat systems (LCS) are at the core of the nation's ability to defend or occupy territory. The U.S. national security strategy is built upon the ability to back up diplomacy with the full spectrum of military action anywhere in the world. Without a viable land combat force, the United States cannot implement that strategy.

Changing world scenarios over the past several years have allowed U.S. leaders to shift budgetary resources away from defense procurement. The result is a significantly smaller LCS industrial base that is looking to a cooperative partnership with the government and a vision crafted by the government for its survival.

INTRODUCTION

> *The primary reason for the existence of all the US Armed Forces is to provide the military power to deter war. Should deterrence fail for reasons beyond our control, then these forces must be able to fight and win. There is no cheap way to do this. There also is no second prize in the business of war today, nor will there ever be.*
>
> --General George H. Decker

In our study of the land combat systems (LCS) industry, we examined the structure, health, and outlook of the various sectors that make up the industry. We limited the scope of our study to tracked and wheeled vehicles in the numerous configurations of combat, combat support, and transportation systems for those two chassis types.

Throughout our study, we sought answers to the following basic questions:

- What is the current condition of the U.S. defense's industrial base?
- What is its future role as an element of national power?
- Does the nation need to keep producing in order to sustain the force?

- Does the nation need to keep producing in order to sustain the LCS industry?

- Can the nation afford to maintain the industry? Can the nation afford *not* to?

- Can the nation afford the degree of excess capacity and surge capability that currently exists?

How the United States chooses to deal with the challenges ahead will directly affect its ability to remain a world leader on economic and security issues. This report outlines the current conditions that we see, the challenges for tomorrow, and the steps the government and industry can take together to meet those challenges.

THE LCS INDUSTRY DEFINED

Our study focused on the two major segments of the LCS industry: tracked vehicles and wheeled vehicles. While we certainly consider other segments, such as small arms, towed artillery, and the like, to be viable components of land combat, we did not have the opportunity to adequately study those segments and did not discover any significant issues from the observations we did make. The two areas of focus are defined below.

Tracked Vehicles

Tracked vehicles are designed to carry out functional mission requirements in almost any type of terrain and to survive, within reasonable risk limits, known and projected threats. Today's domestic tracked vehicles include M1-series Abrams Tanks, Bradley Fighting Vehicles, M109A-6 Paladin Self-Propelled Howitzers, M-88A2 Hercules Recovery Vehicles, Armored Combat Earthmovers, and the Multiple Launched Rocket System. Proposed systems include the Grizzly Obstacle Breacher and the Marine Advanced Amphibious Assault Vehicle.

Armored combat systems normally achieve survivability through the addition of protective layers of steel, aluminum, titanium, or composite protective materials. These materials add weight to a system, which reduces maneuverability and deployability and raises cost. But the

increased survivability enhances the lethality of the system, which somewhat justifies the additional cost.

Integrated command, sensor, and fire-control technologies can also significantly enhance survivability and lethality. These systems help determine the enemy's location and target him with a lethal first-round hit before he even knows an adversary is in the area.

Developing the appropriate balance of defensive protection and high-technology offensive capabilities requires a sophisticated government/industry development team. The technologies required are inconsistent with traditional commercial vehicle manufacturing. Combat systems require specialized materials produced in low quantities.

Wheeled Vehicles

Wheeled vehicles support the combat arm by transporting personnel, equipment, petroleum products, critical supply items, ammunition, food, and water. They also provide mobility for command, control, communications, and some weapons systems.

Today's domestic wheeled vehicles include a variety of platforms that fall into three major categories by carrying capacity: light, medium, and heavy. Wheeled vehicles in production include:

Light. The High-Mobility Multipurpose Wheeled Vehicle (HMMWV), currently in production at AM General.

Medium. The Family of Medium Tactical Vehicles (FMTV) in 2.5- and 5-ton versions, currently in production at Stewart and Stevenson.

Heavy. The Heavy Equipment Transporter, Heavy Expanded Mobility Tactical Truck, Palletized Load System, Logistics Vehicle System, and a number of special-purpose vehicles currently in production at Oshkosh Truck Company.

The wheeled-vehicle fleet must be able to traverse terrain and distances similar to those that their supported combat forces must traverse and move at speeds that allow them to perform the full spectrum of their

missions. Survivability is not as high a priority for tactical wheeled vehicles as for tracked vehicles since the former seek to avoid engaging the enemy, but load capacity, mobility, and reliability are fundamental to supporting the combat arm.

Tactical wheeled vehicles have more requirements in common with commercial industry vehicle requirements than do armored tracked systems. Also, their design is less subject to change with evolving threats. Therefore, off-the-shelf components and production technologies can more often satisfy military requirements with little modification.

CURRENT CONDITIONS

World conditions have changed markedly since the late 1980s, and the defense procurement budgets of the United States and most European countries have fallen dramatically in response. Production plants that were once booming are now making drastic changes in the way they do business just to survive. (Gansler, 1995)

The Department of Defense (DoD) is rescoping many of its end-item procurement programs by stretching out or reducing deliveries. In essence, the dissolution of the Soviet threat led to a fundamental reduction of combat forces--30-35 percent on the average for the United States and even more for some foreign countries. Base closures and the redeployment of many forward-based forces sent combat and combat-support end items into long-term storage or to foreign governments through defense cooperation or foreign military sales (FMS) programs.

As a result, new production requirements are much lower than they were several years ago, particularly in tracked vehicles. For example, the M-1 tank inventory--now assigned to the reserve components as well as to active duty units--remains at roughly 8,000 vehicles. About 600 tank chassis are programmed to be used for the proposed breacher and bridging programs, which still leaves adequate attrition platforms to cover near-term shortfalls in production surge capability.

The U.S. wheeled-vehicle inventory is aging beyond its projected life cycle, however, and several replacement and refurbishment programs are in the works. They are discussed in the Outlook section.

Industrial competition for the remaining business is intense, as it cannot support all of the primary defense production contractors in place only a few years ago. In response to shrinking defense procurements, surviving contractors are exploring all possible means of cutting expenses and increasing efficiency.

Downsizing

Reductions in government procurement contracts have driven almost all of the producers of LCS to dramatically cut back on personnel. Reductions in the 50-85 percent range are not uncommon throughout the industry. These drastic cuts in personnel created a new concern: a "graying" work force as downsizing based on seniority forces younger workers out of their jobs and hiring freezes keeps them away. Within a few years, a significant portion of the older workers will be eligible for retirement, and the specialized knowledge and skills they possess will be hard to recover. (LeBoeuf, 1995)

The intent of downsizing is to improve efficiency, but results to date are inconsistent. Downsizing has displaced large numbers of skilled workers. Some have been able to find employment elsewhere by transferring into related fields, but many have been forced into labor areas that make little use of their skills. Workers may be fortunate enough to retrain into a job with roughly equivalent pay, but in many cases they have been forced to take lower-paying or temporary positions.

Consolidations, Mergers, and /Alliances

As the demand for military hardware continues to decline, mergers have become a means of survival for companies. The most prominent example is the merger between the FMC's Defense Systems Group in San Jose, California, and HARSCO's BMY Combat Systems Division in York, Pennsylvania. The resulting entity is called United Defense, Limited Partnership, now the largest U.S. manufacturer and systems integrator for tracked, armored combat vehicles.

As the sole producer of main battle tanks for the U.S. government, General Dynamics Land Systems (GDLS) is seeking ways to diversify its product line to compensate for the loss of tank orders. Recently, GDLS

bought Teledyne Vehicle Systems in order to expand into the combat information system and engine businesses.

In 1995, Oshkosh Truck Company, the primary producer of heavy wheeled vehicles for the DoD, established a strategic alliance with Freightliner Truck Company that calls for Oshkosh to market certain specialized commercial products through Freightliner's distribution system and to build several series of Freightliner's severe-duty trucks. As part of the agreement, Freightliner will transfer its noncommercial military business to Oshkosh, broadening Oshkosh's defense product line and strengthening its worldwide business. Oshkosh is also currently working with Mercedes Benz to distribute its products in South America and is seeking opportunities to build trucks overseas in joint ventures with other foreign companies.

Shrinking Supplier Base

The low production rates required for military-unique parts make it exceedingly difficult for suppliers to remain profitable. Many suppliers who have commercial alternatives are getting out of the defense business. As prime contractors strive to keep their vendors in the business, they often find the vendors responding in a "take-it-or-leave-it" fashion, with the obvious resulting negative impact on the price and availability of necessary items.

Other suppliers, who do not currently have commercial alternatives, are either finding some or going out of business. Prime contractors often find it necessary to provide management and financial assistance to their suppliers to keep them viable.

Excess Capacity

Current production facilities were generally built to handle Cold War requirements for major end items and accommodate a mobilization surge capacity. None of the manufacturers considered in this report are using their production facilities at anything close to capacity. In fact, some are producing at as little as 10 percent of capacity.

In their efforts to improve efficiency and quality at lower quantities, some contractors have converted their "production-line" arrangement into a "multiple-bay" approach that allows simultaneous work on various configurations of equipment. While the bay approach serves flexibility well, it creates additional training requirements, as workers stay with the vehicle in the bay and perform many more tasks on one vehicle than they used to perform on the production line.

CHALLENGES

Given the current political and economic trends, defense procurement budgets are not likely to increase significantly. As a result, the LCS industry is undergoing a period of substantial transition to the defense requirements of the post-Cold War era. The industry is facing continued pressure to produce less costly, technologically superior products in lower quantities.

Unit costs throughout the industry continue to increase at alarming rates as a result of smaller production runs, greater technical sophistication, and the demand for leading-edge capabilities. Industry officials are attempting to deal with this problem in a variety of ways. We witnessed personnel reductions, restructuring, the implementation of just-in-time inventory management, the integration of commercial components into weapon systems, and labor/management teaming as productive means of improvement. Other efforts focus on maintaining or increasing production quantities through a greater reliance on international orders and expansion into civilian markets in the hope of reducing unit costs. These measures have been only somewhat successful. Unit costs continue to rise. Burdened with excess capacity, huge overhead expenses, and the cost of sustaining viable sources of supply, the industry is hard pressed to keep costs down.

In a declining market, reductions in the supplier base are inevitable. To cut costs, prime contractors are trimming their supplier base by eliminating multiple sources and concentrating on the most efficient suppliers. The DoD lacks sufficient visibility into the supplier base to adequately assess its health, but problems with the supplier base, combined with a demand to meet unique military specifications, could greatly increase the lead time for future production and degrade the

quality of future systems. While acquisition reform initiatives hold some promise of correcting these problems, reform is slow in coming, and reform initiatives alone are unlikely to sustain the supplier base.

Regulatory Constraints

Facing the reality of dwindling U.S. military demand, manufacturers are attempting to expand their business base and diversify into related industrial fields. However, overly restrictive regulations often hamper these initiatives. For example, efforts by the Lima Army Tank Plant (a government-owned, contractor-operated facility) to increase efficiency by taking in commercial work have proved unsuccessful. Despite the fact that the facility's high overhead is the result of excess capacity related to government workload, regulations require that total overhead costs be spread equally between government and commercial work. These additional costs, of course, make the commercial workload less competitive.

U.S. antitrust laws are also affecting U.S. defense companies' ability to adjust to the new defense market environment. U.S. companies, but not foreign competitors, can be restricted from entering into some types of domestic cooperative arrangements. These restrictions hamper the U.S. ability to compete effectively in an increasingly global marketplace.

Business economics is creating a serious problem for research and development (R&D) within the civilian sector. The trend among several of the industries that we visited was to be less concerned with long-range investments than with short-term profitability, at the expense of future technological advancement. Corporate-funded R&D efforts are now more closely tied to developing improvements that lead directly to a marketable product, for which the payoffs are quicker and involve less risk, than to R&D for exploratory science. Consequently, the investment in pure science seems to be gravitating toward government and government-funded labs. This trend appears, at least on the surface, to be detrimental for truly innovative research that may help the nation fight in tomorrow's revolution in military affairs (RMA)-style warfare. The lack of R&D for pure science may be mortgaging future U.S. competitiveness on the open global market.

The development of entirely new systems deserves greater emphasis. The new technologies that are evolving in information dominance, information warfare, command and control, delivery systems, and even nonlethal weapons have the capacity to completely change the face of war. How those technologies interface with U.S. LCS could have a significant impact on the quantity and type of procurement efforts in future years.

International Industries and Markets

We were very fortunate to have the opportunity to visit four of Europe's finest corporate producers of LCS. All were quite capable firms facing many of the same challenges and issues that U.S. defense firms face--dwindling budgets, downsizing, concerns about their supplier base, and integration of commercial ventures.

Like U.S. firms, European firms see international marketing and sales as vital to their survival as defense producers and seek to continually improve their competitive stance. They voiced frustration with U.S. "Buy America" statutes that constrain them from competing in the United States. They found that developing partnerships in the United States was the difficult and often cost-prohibitive path to entering the U.S. market. Their global marketing efforts largely exclude the United States, but they do compete with producers of U.S. defense equipment elsewhere around the globe.

The foreign industries we visited included:

- *Steyr-Daimler-Puch* of Vienna, Austria, producer of specialized vehicles, including armored vehicles, bank security vehicles, airport security vehicles, specialized equipment, and commercial products.
- *TATRA* of Koprivnice, Czech Republic, producer of heavy trucks optimized for off-road travel through the use of an unusual suspension system based on a central-tube construction with swinging half-axles.
- *IVECO* of Ulm, Germany, a subsidiary of Fiat. IVECO produces light, medium, and heavy trucks for commercial and military use from a completely integrated production line.

- Vickers Defence Systems of Newcastle, United Kingdom, producer of main battle tanks, light tanks, armored repair and recovery vehicles, and other specialized items, with joint ventures in the United States and Germany.

OUTLOOK

Predictions are hard to make, especially about the future.
--Yogi Berra

The DoD Industrial Assessment for Tracked Combat Vehicles, dated October 1995, states that "ongoing programs . . . generally will be sufficient to sustain required industrial capabilities." We agree with that assessment for wheeled vehicles, but whether the same goes for tracked combat vehicles depends on the definition of *sufficient*. If *sufficient* means enough business to keep the current suppliers of tracked vehicles producing at minimum sustaining rates, then the report is accurate. Any assumption beyond that is optimistic.

Upgrade programs will remain the primary source of production for the M1 tank line. Companies will preserve their production lines for other tracked-vehicle programs and for wheeled-vehicle programs by stretching out deliveries over longer time periods without increasing the total quantities purchased. The life of the aged 2.5-ton truck fleet will be extended through a rebuilding program at AM General. Both segments of the vehicle industry will actively seek foreign buyers to offset dwindling U.S. demand. Foreign competition will continue to be tough.

Short-Term Outlook (One to Five Years)

Business conditions for the tracked combat vehicle industry will be tight. New vehicle production will remain very low and will be almost entirely attributable to foreign military sales (FMS). Domestic military requirements will continue to focus primarily on upgrades to existing systems. The time to produce a certain number of purchased vehicles will extend several years beyond what is necessary in an effort to preserve active production lines.

Projected near-term business appears stable and sufficient in the tactical wheeled-vehicle industry. One of the lessons learned from Desert Storm is that the U.S. tactical wheeled fleet could not keep pace with the demands of U.S. ground combat vehicles. New production programs, such as Stewart and Stevenson's FMTV, and rebuilding programs, such as the Medium Tactical Truck Remanufacturing program, currently out for proposals, will provide enough business for the prime contractors to remain profitable for the next several years. Any international sales will add to the production demands and assist in offsetting overhead rates. The rate of current production operations appears sufficient over the next five years to exceed minimum sustaining rates.

Long-Term Outlook (5-20 Years)

We expect base force requirements to stabilize or possibly even continue to decline, unless an extended regional or global contingency drives up attrition. A more likely long-term outlook is for the defense budget to stabilize. However, the industry must assume a continuing decline in the defense budget.

Annual orders for new, upgraded, and rebuilt vehicles will not rebound from the current trend toward minimum sustaining rates. FMS alone will not provide the profits required to offset continuing low U.S. defense requirements. Competition in the FMS market will intensify. If current global market conditions continue, U.S. weapons systems will not be superior enough to capture market share. Rising production costs will mean higher weapon system costs.

The prospects for a new generation of combat vehicles, such as the Future Main Battle Tank projected for fielding in 2015, may not be promising enough to retain the prime-contractor base as it exists today. Sound business management practices warrant industry action to cut costs in order to remain profitable and survive. Some of the remaining prime contractors may decide to forgo defense business for the potentially profitable commercial sector, as will an even greater portion of the supplier base.(Naylor, 1995)

Industry's Reaction

The real damage done by the declining defense budget is in the supplier base. Some prime contractors have already eliminated as much as 70 percent of their supplier base in an effort to trim costs. Their intent is to build long-term relationships with selected vendors for what little business remains in the defense industry. Those vendors will also be asked to share some of the risks not normally passed below the prime contractor level. The practice of developing multiple vendors for like items is no longer affordable.

Corporations that decide to stay with defense business will take the necessary actions to remain profitable as defense budgets continue to decline. As corporations streamline and eliminate excess capacity, surge capability is eliminated, too. In our view, even today the industry's surge capability is constrained by what the current work force can produce on current production lines operating up to the levels that the suppliers can support. Therefore, surge capacity levels are really dictated by the supplier base. Even if the prime contractors could muster the work force and regenerate the production capacity to surge in the event of a national emergency, the supplier base would have to match their needs. The risk that the supplier base would fall short is greater in the tracked-vehicle than in the wheeled-vehicle base.

Corporate reactions to declining defense budgets go beyond downsizing and mergers. In domestic corporate teaming, a growing phenomenon, corporations share the risks associated with available contracts and the profits available in a declining market. In the view of the team members, it is better to share a reduced profit than to stand alone in financial ruin.

Expansion into Commercial and Foreign Markets

As demand for defense system end items evaporates, contractors are forced to look for new business opportunities in order to survive. Now more than ever, contractors are aggressively pursuing business in the international market. FMS have become an important source of income for many manufacturers. Remanufacturing, upgrading and technical insertion programs, once only sidelines, have become mainstays for several manufacturers. Where possible, U.S. and foreign manufacturers

are seeking to change their customer base by expanding the commercial portion of their businesses.

The LCS industry is exploring the use of existing production facilities for commercial as well as defense-related business. It appears easier for the tactical wheeled-vehicle industry to capitalize on dual-use opportunities, as the manufacture of wheeled vehicles involves few critical processes that are unique to defense-related production. In times of national emergency, commercial industry could meet the demand for wheeled vehicles with minimal changes to meet military specifications.

Commercial opportunities are not as readily apparent in the tracked combat vehicle industry. Options for dual usage are fewer, and identifying critical processes that are unique to that industry is difficult. In discussions with several production representatives, we could not build a strong case for preserving production over process. Ballistic welding may be one exception. However, manufacturers could surely identify ways to preserve a few specialized processes at a cost much less than that associated with full production.

The tremendous success and wide exposure of AM General Corporation's HMMWV during the Gulf War helped generate interest for a commercial version, which the company calls the HUMMER. Despite early distribution network problems, the HUMMER is now considered a commercial success. Already accounting for 20 percent of sales, the HUMMER is a growing part of AM General's product line.

Both domestic and foreign producers are exploring the virtues of international partnerships. Motivated by the possibility of gaining a competitive edge in the global market or cutting development costs by using internationally available technology, U.S. firms seem more willing to form partnerships with foreign counterparts. Given U.S. "Buy America" statutes, partnerships are often the only way that foreign firms can enter U.S. markets.

Supplementing domestic sales with international sales is desirable but difficult. However, international sales are helping much of the U.S. LCS industry maintain minimum production rates. Capturing an even greater

share of international sales opportunities could do even more to sustain the U.S. defense base.

GOVERNMENT GOALS AND ROLE

In the defense industry, corporations formulate strategy based on the projected needs of the customer, in this case the U.S. government, and the desire to make a profit. For its part, the DoD must chart the course for the future of the defense industrial base. What corporations need is a clear vision of future DoD needs, the ground rules for surviving in this new environment, and some assurance that the DoD will be consistent in its vision of the future.

Clear Vision

First, the DoD needs to work with industry to develop a vision of tomorrow's force requirements. The first question to ask is whether tomorrow's tank will look anything like today's. Will it be made of the same materials? Will it be the same size? Will it even be a manned tank? To formulate a vision of the extended future, the DoD should assess whether the tank as currently conceived has a place on the battlefield. Involving industry prime contractors and suppliers from the earliest planning phases will shorten the developmental process.

Acquisition Reform

Next, the government needs to follow through on promises to reform the acquisition process. One of the DOD's current efforts is to implement efficiencies from commercial procurement processes. Key government leaders consistently extol such tenets of acquisition reform, but the industry, anxious to embrace the new vision and put it into practice, continually finds itself forced back to old inefficiencies by midlevel government employees who have not enacted changes in process with the same urgency as their leaders have.

Government leaders are working hard to make acquisition reform a success. Newly mandated integrated product teams will quicken the milestone review process, and redefined acquisition life-cycle requirements

will shorten development-to-production times, as will concurrent developmental phases when conditions warrant.

Perhaps the most important challenge for government leaders in Congress and the executive branch is to revise the budgeting process. Acquisition reform challenges managers to run their programs more like private enterprises, but the current budgeting process does not allow for prudent business decisions across fiscal years. Program managers have only near-term financial decision authority that is limited by money tied to specific fiscal years. To make industrial production more efficient and save the government billions of dollars, the DoD should commit future acquisition programs to a funded life-cycle schedule. The United States requires such a commitment from FMS customers when they buy major systems, and they follow the schedule; so can U.S. managers.

Preserve the Process or the Product?

The government also needs to determine what it intends to do about preserving the industrial base. If the intent is to preserve a warm production-line capability, then current conditions are a cause for concern. The intent, however, appears to be to produce selected items at a low rate over multiple-year periods Such low-rate production leads to higher unit costs and greater disruption to troop units because of prolonged fielding periods. Although the prime contractors can adjust to this methodology, the supplier base suffers.

The alternative approach is to preserve only the specialized and critical processes necessary to regenerate production capability in case of an extended crisis. This course of action allows the commercialization of much of the remaining industrial base. The cost of preserving specific processes is certainly far less than that of preserving the industrial base through production.

To preserve production lines is to commit to materials and building processes as they are today. Preserving processes instead of production lines may or may not mean a commitment to today's technology. The discovery and development of new materials may lead to production processes totally different from those used today.

If continued low-rate production is the chosen alternative, the DoD needs to reassess surge requirements and let industry maximize its efficiencies. In some instances, corporations are still contractually compelled to maintain additional facilities and equipment in order to meet unnecessary surge levels, but their suppliers are ill-equipped to match surge requirements in time to support the time lines.

Under the assumption that future military conflicts will be violent but brief, process protection might not convert to end-item production in time to support military operations. But that risk may not be a major one. Protecting processes instead of production lines supports the concept of a graduated military response to whatever national security threat exists.

Protecting production lines is difficult to justify strictly from the viewpoint of the requirements of an active military force . The justification is more suited to the protection of the defense industrial base, specifically, preserving business opportunities for current defense contractors. The question for the government is whether the United States can afford this luxury much longer, and the answer will trigger the next set of alternatives offered by government and industry alike.

Level Playing Field

Even though U.S. military equipment and follow-on support are the finest in the world, government support, or lack of it, can easily tip a competition. The U.S. government should assess all avenues to leveling the international playing field for U.S. industries. Several foreign governments work in concert with their industries through political support and tax incentives. For example, certain governments promote their defense industries through direct solicitation, some foreign tax laws allow industries to claim incentive subsidies as business expenses, and several foreign governments subsidize their defense contractors to offset costs. None of these practices is acceptable in the United States

U.S. defense corporations, which are working hard to compete in a growing global sales market, are not asking the government to use its economic power to give them an unfair advantage. They ask only that the government not place them at a disadvantage in the international marketplace. It is time to review some of the rules constraining U.S.

corporations internationally. The spirit of acquisition reform can and must permeate the entire defense industrial base, including all the rules and regulations the government levies on industry. After all, an FMS is still a sale that helps maintain a viable national industrial base.

CONCLUSIONS

> *This nation can afford to be strong--it cannot afford to be weak. We shall do what is needed to make and to keep us strong.*
>
> --John F. Kennedy

LCS industries are coping with cutbacks in defense spending by downsizing, consolidating, merging, and integrating commercial and military production facilities. The results of these efforts include improved efficiency, a smaller work force, a higher per-unit cost due to low-rate production, and reductions in the supplier base.

Upgrade programs and FMS contracts are marginally sustaining tracked-vehicle production. The wheeled-vehicle industry outlook is brighter than that for the tracked-vehicle industry as a result of ongoing and upcoming acquisition and rebuilding programs. International markets are open, but competition from foreign industry is tough in markets outside of the United States.

The domestic industry will survive, but the government must cooperate if the United States is to preserve an affordable production base. Government-industry partnerships will be an important part of optimizing program efficiencies with limited funds. Clearly defined long-range plans and multiyear contracts are two keys to improving the affordability of land combat systems. Lethality advances incorporated from RMA technologies may allow combat superiority with a smaller force structure.

The benefits of acquisition reform are slow to evolve. Top-level government and industry leaders agree that reform is necessary, but midlevel program executors appear to be slow to capture the spirit of reform.

Future military conflicts will most likely be resolved with the weapons system inventories on hand. The government can no longer afford to

preserve costly excess capacity and surge capability. Integrating the production of defense-related items with that for commercial items is a more efficient use of facilities and technology.

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MUNITIONS INDUSTRY STUDY REPORT 1996

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ABSTRACT

The munitions industrial base is in the process of adjusting to changes in the strategic environment. Reductions in munitions procurement are threatening the United States's ability to meet national security objectives.

- The reduced demand for munitions worldwide *cannot maintain the current industrial base.*
- The U.S. industrial base *continues to shrink* as a result of low production requirements.
- *An increase in global competition* is eroding the U.S. competitive advantage.
- Global partnerships and *cooperative arrangements* will become the mainstay of industrial survival strategies.
- New *relationships between government and industry* must emerge to allow for new cooperation and partnership agreements.
- The current stockpile of "preferred" precision-guided munitions (PGM) *may not support a strategy based on two major regional contingencies* (MRC) in the near term.
- *No major government intervention is required* at this time to bolster the U.S. munitions industry.

INTRODUCTION

This report assesses the current state of the U.S. munitions industry, the challenges it faces, and its outlook. We also offer recommendations to the government and the industry for the continued health of the munitions industrial base.

Our assessment of the industry is based on research, discussions with representatives of the government and industry, and visits to contractor plants and government installations in the United States, and Europe (i.e., the United Kingdom, France, and Germany). Most facets of the industry

were represented--from the extremely high-technology areas of precision-guided multiple warhead missiles to the generally lower-technology, industrial production of bombs, explosives, and propellants. At each location, we investigated the latest munitions technologies, systems, programs, business practices, and challenges. Our study of the industry was enhanced by guest speakers from the Offices of the Secretary of Defense (OSD) for Industrial Affairs and Science and Technology, the U.S. Army Single Manager for Conventional Ammunition (SMCA), the Munitions Industrial Base Task Force (MIBTF), the Air Force Program Executive Office for Conventional Strike, and the Army Industrial Operations Command.

THE MUNITIONS INDUSTRY DEFINED

The sheer number of components in the industry made a thorough analysis of every product impossible within the confines of the study. Therefore, we divided munitions into three sectors: ammunition, which includes such munitions as projectiles, bombs, fuses, mortars, mines, explosives, and rockets; precision-guided munitions (PGMs), which consist of all classes of conventionally armed guided missiles, smart bombs, and torpedoes; and weapons of mass destruction (WMD), which cover nuclear, biological, and chemical weapons. The characteristics of the industry as a whole are shown in Table 1.

Table 1. Salient Features of the Munitions Industry

Is essential for military readiness	Requires long lead times for production
Entails high risks	Uses limited production runs
Is mature	Is dangerous (because of hazardous material used)
Produces a unique military application	Entails extensive land requirements (for safety, testing, etc.)
Is a monopsony	Is difficult to enter

Today's munitions are complex and sophisticated. They use a wide variety of technologies, including nuclear physics, advanced case technology, stealth (low observables), optics, advanced and agile manufacturing, composite materials, metallurgy, metal machining, guidance and

navigation systems, software, fusing, microelectronics, propellants, and explosives.

The munitions industry, like the rest of the defense industry, is shrinking. The move is toward greater consolidation and more partnerships among domestic and international corporations as producers strive to survive and achieve economies of scale.

Excess production capacity remains in both the private and public sectors of the industry, even after dramatic downsizing and consolidation. Production rates are 30-40 percent of capacity, according to some industry representatives. Declining production exacerbates the effect of high overhead costs, which increases prices and forces firms to reduce costs further in order to remain competitive. The number of firms leaving the industry reflects the magnitude of the problem. As of 1996, only 52 prime, privately owned contractors remained in business, compared with 286 in 1978.

New relationships are forming under teaming and systems management arrangements. Firms that were once bitter rivals are now partners in the marketplace. Competition has taken a new turn, and cooperation, the new strategy for competing for limited defense dollars, is leading to further consolidation in the munitions industry, thus further limiting competition.

Cuts in Department of Defense (DoD) procurement dollars (reduced 75 percent since 1985) have hurt the munitions industry. An analysis of munitions funding from FY 1996 through FY 2001 indicates that available resources trail requirements by more than $20 billion. The chairman of the Joint Chiefs of Staff, Gen. John Shalikashvili, asked Defense Secretary William Perry to increase arms procurement in fiscal year 1997. Warning of dire consequences if the decade-long plunge in defense procurement spending is not reversed, the chairman said that $60 billion per year in procurement funding was required to adequately recapitalize (including munitions).

High quality remains the hallmark of the U.S. munitions industry. Statistical Process Control techniques and International Standard Organization 9000 certification further promotes high-quality workmanship in the munitions industry. In the past, mass and high-volume

production were the key to the munitions industry's profit, but today the industry tends toward limited-quantity production, which in some cases does not fully support the use of automation, thereby reducing efficiency and possibly profitability. Munitions are produced in government-owned, government-operated (GOGO); government-owned, contractor-operated (GOCO); and contractor-owned, contractor-operated (COCO) facilities. Each of the armed services is responsible for its own peculiar munitions (e.g., U.S. Navy torpedoes); however, the U.S. Army, designated the SMCA, oversees the acquisition and production of conventional ammunition for all the services.

The international demand for munitions has declined significantly in recent years and, even in the most optimistic forecasts, exports cannot compensate for the excess defense industrial capacity that currently exists. The international market has led to intense competition for export sales, which have become more important to the financial viability of defense contractors as their domestic business base declines. Southeast Asia and the Middle East are currently the only growing markets for military equipment, including munitions, while demand elsewhere has generally decreased.

Five countries--the United States, the United Kingdom, France, Germany, and Russia--account for 86 percent of export arms sales, with China a close sixth. France and Russia in particular are very strong competitors in the PGM market.

AMMUNITION

Munitions in this sector include products that contain some type of energetic material (such as explosives and incendiaries) and are unguided after they are fired. (Small-caliber ammunition was not part of the study.) Ammunition items are becoming increasingly sophisticated, employing highly sophisticated fuses and penetrators constructed from advanced materials.

The ammunition industrial base relies heavily on defense requirements, and it products have few commercial applications. The establishment of an ammunition production facility requires large capital investments in equipment as well as considerable real estate in remote areas.

Current Conditions

The ammunition production base, both government and contractor, has declined drastically as defense has downsized. The large decrease in COCO plants is the result of contractors consolidating, going out of business, or leaving the ammunition industrial sector. The GOCO base is being reduced to six active ammunition plants. Of the remaining plants, six became Group Technology Centers (GTCs) in the 1990s under the AMMO-FAST 21 concept in an effort to retain critical core capabilities and technical skills. Each GTC is responsible for several families of ammunition, such as tank ammunition, grenades, or small arms.

Reductions in ammunition funding have been dramatic. With the exception of increases to support Desert Storm, ammunition funding has declined at a rate twice that of the rest of the DoD acquisition budget. From a $5.6 billion industry high in FY 1985, the budget reached a low of $501 million in FY 1994. FY 1995 and FY 1996 saw an increase to just over $1 billion through congressional add-ons to the DoD budget. As the government minimizes its funding of research and development (R&D) programs, the private sector, faced with increased costs and decreased production, is hard pressed to bear the burden of R&D funding. Thus, advances in technology, which gave the United States its edge in the past, may be at risk. The drastic reductions in finding have caused the industrial base to shrink and have made it very difficult for the ammunition sector to remain solvent.

- The MIBTF, consisting of representatives from companies in the ammunition production base, completed a study of the ammunition production base in October 1993. The task force concluded that:

- The base could not support demands for the most modern, "preferred" ammunition for one major regional contingency (MRC), much less two simultaneous MRCs.

- Production capacity was insufficient to meet the requirement to replenish ammunition stocks after a conflict.

- The munitions industrial base was in crisis and could be saved only by

increased, steady spending on ammunition (Strategic Assessment Center, 1993).

A 1994 follow-up review by the MIBTF reached essentially the same conclusions.

In contrast, studies completed by the OSD in 1995 found that although considerable financial distress exists within the base, both the production capacity and the technological capability of the ammunition sector are sufficient to meet the DOD's requirements for ammunition production and replenishment (Industrial Operations Command, 1995). The OSD recognized that industry has responded to reduced ammunition procurement by restructuring, shrinking, and, in some cases, closing factories. The result may be more single producers for certain products and the need to contract with a sole source for ammunition needs. The OSD concluded that the situation did not threaten the DOD's ability to supply the armed forces with sufficient quantities of high-quality ammunition.

The great differences in the conclusions drawn by the MIBTF and the OSD are largely the result of differing preliminary assumptions. For example, the OSD study sent 154 letters to producers in the base but received only 29 responses. The OSD assumed that if a company did not respond to the data request, it was financially healthy, even though companies in financial distress may have been reluctant to provide adverse financial information to the government for fear that it might jeopardize their consideration for future contract awards. If the OSD had assumed financial distress rather than health for companies that did not respond, the results in all likelihood would have been very different. As for the MIBTF study, the fact that the task force was composed of representatives from companies whose very survival is dependent upon defense ammunition budgets understandably affected their conclusions. Notably, it was in response to the MIBTF view that Congress increased ammunition budgets in FY 1994 ($1 million), FY 1995 ($300 million), and FY 1996 ($300 million).

Our study concluded that the health of the base is more robust than that presented by the MIBTF but less stable than the optimistic OSD view.

After examining the replenishment issue in its March 1995 Function Area Assessment for Ammunition, the Department of the Army's SMCA concluded that replenishment times for *every family* of ammunition were within Defense Planning Guidance (DPG) requirements. However, the SMCA cautioned that continued drawdown of war reserve stocks to meet training needs could erode this capability. Moreover, for a few individual ammunition items *within a family*, replenishment times were not within DPG boundaries. The army is studying these items in order to take corrective action.

Challenges

- The huge U.S. ammunition stockpile contains more than enough ammunition to fight two MRCs but consists largely of older, less capable ammunition that may not be effective against a future threat. Furthermore, the stockpile is short in the area of "preferred" munitions. Its sheer size results in low production requirements for the foreseeable future and provides an open invitation to expand the use of ammunition in training.

- As the industrial base shrinks, employees retire or are releasedwithout replacements, taking critical industry skills and knowledge with them.

- The industry is experiencing insufficient private sector R&D in the face of limited short- and long-term returns.

- Overhead costs have become a significant challenge because firms operate at uneconomical production rates.

- U.S. producers are increasingly pursuing world markets in fierce competition for scarce defense dollars.

- Foreign competition has increased dramatically as advanced ammunition technology has become readily available worldwide and the U.S. government reduces its investment in R&D.

- Ridding itself of old, unwanted conventional munitions has become a tremendous challenge to the DoD. Approximately 400,000 tons of

conventional munitions, nearly 10 percent of the stockpile, now await disposal. Each year, the services designate nearly 70,000 additional tons of munitions for demilitarization (environmentally safe destruction of unwanted munitions), a potential $70 million annual business opportunity.

Outlook

Although the production and technological capabilities of ammunition support the current national security strategy, there is a shortage of "preferred" munitions, and replenishment time has become a serious concern. In addition, the continuing shrinkage of the U.S. production base may eventually decrease the U.S. capability to replenish stocks and could result in dependency on foreign producers for replenishment.

The shrinking base is causing an increase in the number of sole-source producers, resulting in increased prices, reduced flexibility, and little or no surge capacity. The current stockpile is aging and may become both unreliable and obsolete, given the lack of modernization of munitions and the advancement of future threats.

In FY 1994, the Army Materiel Command and the SMCA described the conventional ammunition base as weak. As a result of government programs and policies, such as AMMO FAST-21, and efforts by private commercial concerns to consolidate, the base stabilized in FY 1995. Although industrial base assessments are incomplete for FY 1996, no significant change in status is anticipated as the base remains in transition.

Over the last 10 years, the demilitarization sector of the munitions industry has exhibited rapid growth. A multimillion dollar opportunity, demilitarization gives aggressive contractors an excellent opportunity to remain in the business, retain key technical skills, and make a profit.

PRECISION-GUIDED MUNITIONS (PGM)

Current Conditions

Although the United States remains the world leader in PGM technology and production, other nations, primarily in Europe, are rapidly increasing

market share. As U.S. and foreign PGM funding levels and production rates are reduced, the procurement of PGMs, as the munition of choice, consumes a larger percentage of the total munitions budget. In fact, Congress reported in 1995 that the military services have bought or are developing 33 PGM types (19 types in inventory and 14 types in development) (General Accounting Office, 1995).

Like those in the ammunition sector, firms in the PGM sector are consolidating, merging, shutting down plants, and laying off skilled personnel in an effort to remain economically viable. The industry is concerned that the loss of critical skills may limit its ability to support future contingencies. The significant lead times required to restart PGM production lines may be aggravated by the lack of availability of suppliers or by outdated technical data packages.

At the same time, there is great debate over whether current PGM stocks are sufficient to support two near-simultaneous MRCs. In our opinion, there is a mismatch between the current U.S. strategy, which reduces platform force structure, and reliance on precision-strike munitions as force multipliers. There are *not* enough "preferred" PGMs for two MRCs. Furthermore, until the new weapons (including global positioning system [GPS]-guided weapons) are fully integrated into the stockpile, the gap between U.S. PGM supplies and requirements will continue.

Another trend is the growing number of joint ventures between U.S. manufacturers and especially among European producers. Although the United Kingdom, France, and Germany are looking more and more toward joint ventures with U.S. firms, such ventures are not currently received with much enthusiasm in the United States, primarily because of concerns about technology transfer.

Both U.S. and European firms are finding it more necessary to export their products. European companies cannot achieve efficient economies of scale unless they get other nations to join in their PGM programs. At the same time, U.S. firms are increasingly dependent on exports as domestic requirements decline. The result is growing collaboration: within Europe to compete with U.S. merged industry giants and between U.S. and European firms not only to achieve economies of scale but simply to survive.

In short, the current approach in the PGM industry reflects the theory that a small part of a big pie is better than no pie at all.

Challenges

Perhaps the most formidable challenge is the necessity to downsize while retaining skills that are critical to the industry. The trend toward international collaborative PGM programs challenges the Departments of Defense, Commerce, and State to find innovative ways to accept and encourage future international cooperative ventures.

In addition, both the government and industry must seek a healthy balance between PGM procurement and R&D funding to ensure future technological competitiveness and maintain U.S. military preparedness through leading-edge technology.

Outlook

The downsizing trend is not over, and PGM producers will have to consolidate further. Because the base has decreased by about 60 percent since 1989, most PGM producers have acknowledged that their surge capacities have been cut by at least the same amount. For economic and political reasons, many PGM producers feel it will be essential to collaborate internationally on future PGM programs.

The study group concluded that while the PGM industrial base will be smaller, it will be highly productive and more efficient. Industry projections of the PGM market show reduced demand, with very limited sales by those contractors who learn to compete globally and are able to survive the contraction. Paradoxically, both foreign cooperation *and* foreign competition are expected as firms unite to survive while developing specific areas of specialized expertise (e.g., fuses, propellants).

Foreign military sales, which capitalize on global demand, could provide significant additional revenue to U.S. suppliers. Historically, however, foreign buyers are influenced by U.S. procurement decisions, which are viewed as signals of U.S. confidence in the system and predictions of availability of continued post-production support. While foreign military

sales have the potential to bolster contractors' revenue, the DoD severely restricts the export of sensitive PGM technology.

WEAPONS OF MASS DESTRUCTION (WMD)

Current Conditions

The U.S. stockpile contains adequate nuclear weapons to support the national security strategy. The goal is to maintain a credible nuclear capability while drawing down an aging inventory that will be extended well beyond its originally intended shelf life. No large-scale development of new warheads is currently anticipated. Today's emphasis is on stockpile management with an absolute focus on surety--safety, security, and reliability.

A large chemical weapons stockpile consisting of 30,000 tons of bombs, projectiles, mines, and rockets is being demilitarized, and no development or new production is planned. Chemical weapons production ceased in the late 1960s, and under international treaty all U.S. chemical weapons will be destroyed. The destruction of the stockpile destruction presents both a challenge to the government and a rare opportunity to contractors in the shrinking defense industry. The total cost of the destruction program is estimated at over $12 billion.

By public law, the United States does not maintain a biological weapons inventory. Aside from a small stock of research agents, the United States does not hold any biological weapons, nor are any in production.

Challenges

Numerous challenges exist in preserving the skills and facilities to effectively maintain the current U.S. capability in WMDs. Without nuclear weapons production, maintaining a reliable nuclear stockpile depends upon critical capabilities that have no corresponding civilian applications, such as the production of tritium and neutron generators.

Under the Nuclear Test Ban Treaty, full, live weapons testing is prohibited. Ensuring the complete reliability of the smaller number of retained nuclear weapons demands a rigorous surveillance process, but

technical expertise in national laboratories is rapidly eroding. Advances in computer modeling and materials testing are essential as the stockpile ages with unknown effects. To make these advances, the industry must monitor and maintain the skills and expertise of the core cadre of experienced engineers and technicians. Aggressive recruitment of young engineers and scientists must continue in order to bolster the work force and to maintain the specialized skills this sector of the industry demands.

The demilitarization of chemical weapons remains a significant challenge. Public Law 99-145 (1985) directed the DoD to destroy the entire chemical weapons stockpile not later than September 30, 1994, but when technical problems and citizen opposition to incineration caused delays, Congress granted an extension to December 31, 2004. The U.S. chemical stockpile will be destroyed in nine chemical incinerators.

The demilitarization of obsolete or treaty-banned chemical and nuclear stockpiles in the United States and abroad poses severe scientific, engineering, and technical challenges that are surpassed only by the unprecedented demands of the cleanup of the environment around production facilities. The technological considerations of environmental cleanup and its cost remain significant challenges.

Outlook

The downsizing of the nuclear weapons industry continues. On February 29, 1996, Secretary of Energy Hazel R. O'Leary announced plans to reduce the U.S. nuclear weapons production complex to 20 percent of peak capacity by 2005. The production base will produce only those nuclear components that support the present stockpile. Personnel will also be reduced by 10-15 percent as parts and maintenance facilities are downsized.

The overall outlook for the U.S. nuclear weapons sector is for a smaller, more streamlined, but carefully tailored industry sized to match the nation's long-term needs. The retention of core capabilities may depend on finding productive commercial uses for the national laboratories.

Reduced R&D activity is the result of decreased funding and prohibitions against live testing. To sustain confidence in the stockpile, ongoing R&D

efforts must focus on the advanced computer-modeling and material-testing techniques required to stay ahead of unknown aging effects.

The requirement to maintain the stockpile must be joined with the necessity to preserve the industrial and knowledge base. The national laboratories, specially equipped as the repository of intellectual property, are not fully occupied or adequately challenged by stockpile maintenance alone. Partnerships with private industry in which costs are shared equally (the work is performed for half the price at the government's expense) are viewed by critics as "good deals" for private corporations and are not without controversy. Transition to private ownership or consolidation may be worthy of consideration and further study.

GOVERNMENT GOALS AND ROLE

International

The European strategy for the munitions industry, dramatically unlike the U.S. strategy, relies heavily on joint international development. The United Kingdom, which has the most progressive and truly competitive government policy, welcomes competition for its munitions requirements from the United States or any other capable manufacturer. Other European governments, particularly that of France, have to deal with many more social constraints (such as limitations on work force reductions) and tend to subsidize their munitions producers. The result is that European manufacturers are less efficient and less able to effect changes that would increase industry productivity.

As the United Kingdom, France, and Germany shrink their industries, they are abandoning the goal of being entirely self-sufficient in *all* of their munitions requirements. Instead, they are retaining capabilities in fewer, selected areas of expertise and relying on imports of components or entire systems for munitions they cannot produce themselves.

The international environment is also complicated by defense offsets (i.e., compensation demanded by foreign buyers as part of a sale), foreign dependency concerns, and inconsistent government export policies. Defense offsets have become critical to securing export agreements. Any

successful export strategy now requires the innovative use of sophisticated offset packages.

United States

The U.S. approach emphasizes a balance between meeting national security requirements and diminishing defense resources. In this vein, U.S. policy is primarily hands-off, relying more on market forces to reshape the industry. Several government initiatives, such as the Multi-Missile Factory and Agile Manufacturing processes, are aiding the industry in identifying more efficient production strategies.

In the current fiercely competitive environment, the governments of some munitions-exporting countries are increasing their support of their industries. The frequency with which senior-level government officials lobby for export sales has been increasing in the past few years. In this environment, the United States has to walk a fine line between being a peacemaker and pursuing aggressively promoting U.S. munitions sales abroad--while not providing taxpayer-funded financial incentives. The U.S. munitions industry needs this balanced support.

Both the government and industry must continually adjust to the realities of the world market. To maintain competitiveness, the government must engage and support industry more actively--not to subsidize it, but to remove impediments to its success.

Although acquisition reform seems to have lost some of its momentum in the last two years, the government is still counting on achieving significant savings in all areas of defense procurement to fund modernization and operations readiness.

In contrast with the European approach of maintaining only selected areas of expertise, the U.S. approach appears to focus on retaining technical expertise in *all* areas of munitions development and production. Current U.S. policy also emphasizes protecting U.S. technologies at the expense of global partnerships. U.S. manufacturers are also somewhat protected by a U.S. practice that procures over 90 percent of munitions requirements from domestic producers.

The increasing U.S. reliance on foreign components has given rise to concern over the level of dependency and calls by industry for protectionist policies. Such policies must be prudently developed and not followed blindly, or they will undermine interoperability and two-way trade with U.S. allies as well as drive up component costs. The United States cannot afford to cut off its access to the best available technologies, which in some cases will be from foreign sources.

In an attempt to improve U.S. international business, the government has recently adopted policies aimed at easing restrictions on forming global partnerships. These initiatives, if successful, hold promise for the future.

Current U.S. export policies are inconsistent, contradictory, and outdated. For example, while policies stress cooperation, the process prohibits technology transfer, precludes jobs offshore, and restricts deals without lucrative offsets. A complete review of government policies--balancing technology transfer concerns with prudent foreign sales opportunities--is overdue. For instance, the U.S. government should reinvent the export-licensing process so that it responds better to the growing number of valid export requests.

CONCLUSIONS

The munitions industry is adapting to changes caused by reduced production requirements and increased foreign competition. The ammunition sector in particular continues to suffer from the defense drawdown. Although the United States remains the world leader in munitions technology, the nation's ability to rapidly produce high-technology weapons on a large scale has diminished.

Findings

- The munitions industrial base continues to shrink as production requirements are reduced. Munitions producers will continue to use consolidation as an industrial survival strategy. Surviving producers will be fewer in number but highly productive and more efficient.

- Although the capabilities of the U.S. PGM stockpile are impressive, current stocks do not support the sheer number of "preferred"

weapons required to conduct two MRCs. The addition of the GPS family of guided munitions will improve this shortfall, but not before the turn of the century.

- As a direct result of the success of U.S. weapons in the Gulf War, the United States became the world's leading supplier of high-technology munitions. Since that time, global competition, especially in the area of PGMs, has intensified to the point where the U.S. competitive advantage is eroding.

- Survival strategies in the industrial base vary from company to company and from country to country. One emerging strategy that almost all embrace is cooperative arrangements and global partnerships. Although the United States is generally considered an unreliable partner by some European Union countries, cooperative agreements will remain a primary industrial strategy.

- New government-industry relationships are emerging as a result of the new requirements for cooperation and partnerships. Industries cannot establish global partnerships unless the government works to remove impediments.

Recommendations

Industry

- To ensure long-term survival, support other government acquisition reform initiatives, such as "best-value" contracting, which emphasizes past performance, and fully embrace the expanded use of commercial acquisition practices with both their customers and their suppliers.

- Support joint government-industry initiatives such as the agile manufacturing concept for ammunition and the multimissile factory initiative.

- Adopt a long-term approach to R&D by investing in efforts to remain competitive in the area of next-generation munitions.

- Continue to identify and seek opportunities to form global partnerships.

Government

- Reinvigorate government acquisition reform, including the full range of innovative approaches, and enforce its implementation at *every* level of government.

- Authorize multiyear funding for munitions programs to provide much-needed stability in funding and production.

- Eliminate duplication of oversight in Congress.

- Overhaul the U.S. export-licensing process to ensure that U.S. producers remain competitive in the global market.

- Fund service PGM requirements fully to support tomorrow's force structure--one that relies on PGMs as force multipliers.

- Stimulate munitions R&D efforts by removing obstacles and providing incentives to industry.

- Continue collaborative partnerships with industry and move toward the privatization of the national laboratories.

In the final analysis, the munitions industry is troubled but not desperate. There is reason for concern, but no major government intervention is currently required other than that recommended in this report.

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SHIPBUILDING INDUSTRY STUDY REPORT 1996

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ABSTRACT

The shipbuilding industry is vital to the United States' s national security strategy. Recent cuts in Department of Defense procurement budgets have called into question the viability of an industry that has relied exclusively upon naval ship construction for the last two decades. If even a few U.S. shipyards are to remain in business, they must reenter the commercial shipbuilding market. To regain even a small percentage of that market, U.S. shipbuilding firms must learn to build ships competitively by streamlining their management structures, employing new manufacturing processes, and revitalizing their labor force.

INTRODUCTION

The power of a nation, especially an island nation like the United States, to respond to global threats requires a maritime capability. Thus the capability and capacity to build large oceangoing vessels for U.S. power projection and sealift is important to the objectives of the U.S. national security strategy objectives.

When the Cold War ended in 1991, the U.S. military began to downsize and the U.S. Navy abandoned its goal of a 600-ship fleet. Orders for new ships were terminated, and long-range forecasts for new Navy ships grew dimmer and dimmer. As a result, many U.S. shipyards closed their doors or elected to focus solely upon ship repair instead of ship construction. Only *seven* privately owned yards were producing large vessels for the U.S. Navy as of March 1, 1996 (*U.S. Industrial Outlook 1996*).

The purpose of our study of the shipbuilding industry was to answer two questions. First, are the capacity and viability of the seven yards sufficient to meet national security needs for the production of both sealift assets and combatant vessels? Second, is it feasible for U.S. shipyards to compete in an international commercial market for oceangoing vessels as a means of preserving U.S. shipyard capacity, capability, and viability?

To answer these questions we visited several U.S. shipyards and spoke with corporate executives and union leaders. We also spoke to personnel from the U.S. Navy--the primary customer of the large U.S. shipyards. In

addition, we examined the commercial shipbuilding market to determine whether U.S. shipyards have the capability to compete in a fiercely competitive market in which foreign governments highly subsidize their home industries. As part of this investigation, we visited foreign shipyards, met with buyers of commercial ships, and examined the role of governments in the shipbuilding industry.

THE SHIPBUILDING INDUSTRY DEFINED

Shipbuilding as an industry in the United States takes into account all of the labor, design, manufacturing processes, infrastructure, repair facilities, and suppliers involved in new construction, conversion, and repair of ships of various sizes and complexity--both military and commercial. The continuum of shipyards includes facilities ranging from huge industrial complexes located in major ports with cranes capable of lifting hundreds of tons to small, labor-intensive, family-owned businesses in remote locations.

The U.S. shipbuilding industry consists of publicly owned (government) shipyards, privately owned (commercial) shipyards, and key subtier manufacturers engaged in design, manufacture, and/or maintenance of naval and commercial vessels and key shipboard systems. Publicly owned shipyards do not build new ships but only conduct ship repair operations.

There is a distinction between those elements of the industrial infrastructure that possess conventional capabilities and those that possess nuclear capabilities. Only two U.S. shipyards are capable of producing nuclear vessels, Newport News (aircraft carriers and submarines) and Electric Boat (submarines only).

Over 220 establishments in the United States are engaged in some form of shipbuilding and repair. The major shipbuilding base (MSB), as identified by the U.S. Maritime Administration (MARAD), comprises privately owned facilities that are open and have at least *one* shipbuilding position able to accommodate a vessel of 122 meters or more (*U.S. Industrial Outlook 1994*). Most of these yards are also major repair facilities with a dry-docking capability. As of January 1996, MARAD's Office of Ship Production identified 16 yards meeting MSB criteria. MSB yards employ roughly 70 percent of the total U.S. shipbuilding and repair labor force.

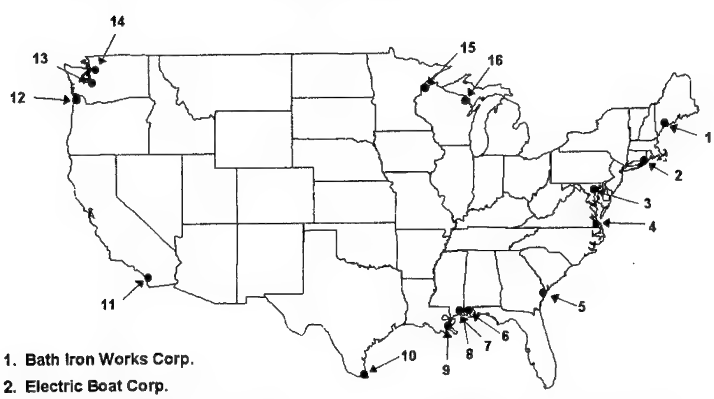
About 90 percent of these employees are engaged in U.S. Navy or Coast Guard ship production or repair (*U.S. Industrial Outlook 1996*).

U.S. shipyards are classified into first-tier shipyards, second-tier shipyards, and third-tier suppliers. First-tier yards include three major conglomerates in U.S. shipbuilding: the General Dynamics Corporation, which owns Electric Boat and Bath Iron Works; Litton Industries, which owns Ingalls Shipbuilding Company; and Tenneco, Incorporated, which owns Newport News Shipbuilding. In addition, 12 other yards make up the first tier (see Figure 1).

Second-tier yards include smaller yards, some with U.S. Navy contracts, that produce other than large oceangoing vessels exceeding 122 meters. These yards construct and repair smaller vessels for inland waterways and coastal carriers. Typical ship construction includes tugs, supply boats, ferries, fishing vessels, barges, drill rigs, small military vessels, and other government-owned vessels (e.g., Coast Guard cutters).

MAJOR SHIPBUILDING FACILITIES IN THE UNITED STATES

JANUARY 1, 1996



1. Bath Iron Works Corp.
2. Electric Boat Corp.
3. BethShip, Sparrows Point Yard
4. Newport News Shipbuilding
5. Intermarine USA
6. Alabama Shipyard, Inc.
7. Halter Marine, Inc., Moss Point Div.
8. Ingalls Shipbuilding, Inc.
9. Avondale Industries, Inc.
10. AMFELS, Inc.
11. National Steel and Shipbuilding Co.
12. Gunderson, Inc.
13. Tacoma Boatbuilding Co.
14. Todd Pacific Shipyard Corp.
15. Fraser Shipyards, Inc.
16. Marinette Marine Corp.

figure 1.

The third tier consists of hundreds of private sector and government-owned industrial facilites that design, develop, produce, and maintain subsystems and components required to support the shipbuilding industry.

CURRENT CONDITIONS

The U.S. shipbuilding industry remains in a depressed state. The number of merchant and naval ships under construction and on order fell from approximately 150 each year in the mid-1970s to under 50 (projected) for 1996. This reduced construction of new ships has played havoc with the shipbuilding industry, resulting in "right sizing" of the labor force and the closing of several yards.

In 1990, 21 U.S. shipyards employed about 130,000 workers of all skill and pay levels. By the first quarter of 1996, only 16 yards employing 106,000 people remained. Some analysts project that by 2000 employment figures may drop to approximately one-half of the current level. Though this reduction may appear alarming, total employment in European, Japanese, and Korean shipyards is around 200,000, and those workers produce approximately 85-90 percent of the world's commercial ships.

Commercial Shipbuilding Trends

During 1995, the number of commercial ships on order or under construction in the world market rose 15 percent over the previous year. This increase followed an upward trend in new ship construction since 1991. The world order book for merchant vessels 1,000 gross tons (gt) and over consisted of 2,655 vessels totaling 48.5 million gt as of December 1995 (*U.S. Industrial Outlook 1996*).

Among the first-tier shipbuilding firms in the United States, two yards received commercial orders in 1995. The contract orders called for over one quarter million deadweight tons (dwt), including four new ships and four major conversions (eight product tankers). Also in 1995, a major second-tier shipyard received two product tanker orders, and during the first two months of 1996 a first-tier yard received an order for five product tankers. This encouraging news follows decades of declining

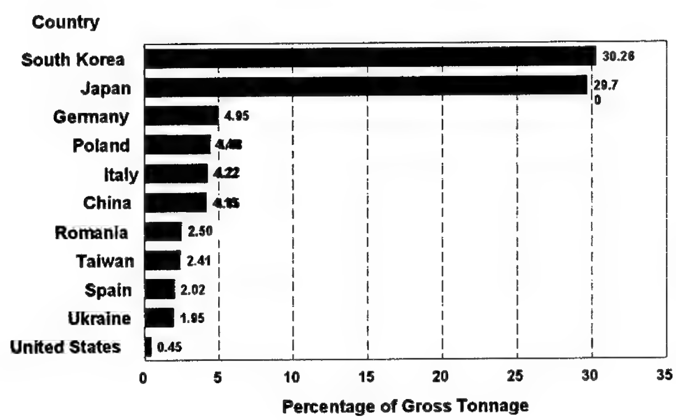
commercial market share: the low point was zero commercial ships of 1,000 gross tons and greater on order in 1987.

Firms in South Korea, Japan, and China, including Taiwan, hold nearly two-thirds of the commercial market share figured as a percentage of gross tonnage (Figure 2). Shipbuilding firms in Europe hold nearly 20 percent of the commercial market share, with Germany holding the largest percentage. The United States ranks 23rd among major shipbuilding nations, *holding less than 1 percent* of the world market share.

Figure 2

WORLD SHIPBUILDING ORDERBOOK

as of December 31, 1995



Source: Lloyd's Register

Military Shipbuilding Trends

U.S. military ship construction has steadily declined since the buildup of the early 1980s. In 1992, 10 Navy vessels were constructed, and by 1995 that number had declined to 6 ships. As of March 1, 1996, U.S. firms had 55 military ships of 1,000 dwt and greater on order or under construction for a total of just under 900,000 tons.

Most first-tier shipbuilding firms continue to rely exclusively on government contracts. Some industry leaders forecast that Navy shipbuilding will remain low for only a few more years and then will

increase by as much as 70 percent, but the shrinking U.S. defense budget and unprecedented pressure to balance the federal budget may mean that the anticipated increase is wishful thinking. The reduced threat to U.S. national security is more likely to translate into further reductions in naval combatants and military sealift requirements.

Current Capacity

U.S. shipyards need to shed their considerable excess capacity. Shipbuilders in the United States would need to build 30-50 commercial ships per year to maintain the current capacity. In contrast, the average number of ships built per year over the last five years was only 3.8 (Snyder, 1996).

Subsidies

Financial and fiscal policies remain crucial issues for the shipbuilding industry. The consequences of government intervention in the shipbuilding industry are contributing to excess production capacity and price cutting, especially in South Korea and Japan. The current commercial market continues to exhibit depressed prices influenced by price cutting (dumping) and tough international competition.

Productivity

A National Shipbuilding Research Program (NSRP) project study on global shipbuilding competitiveness, completed in 1995, compared productivity and competitiveness in four U.S. shipbuilders and five foreign yards. The surveys, taken in 1978 and 1994, show that U.S. shipbuilders are losing ground to foreign competition in the overall level of technology used and specifically in the areas of shop construction, design and engineering, steel work, outfitting, and organization and operating systems (A&P Appledore, 1995).

While the differences in level of technology are very telling, the statistic that best frames the problem is the measure of competitiveness in man-hours (MH) expended per compensated gross ton (CGT). The study determined that the average MH/CGT was 184.4 for the U.S. yards

studied and 88.0 for all foreign yards, placing U.S. shipyard labor productivity at less than one-half that of all foreign competitors.

Another recent shipyard productivity study has put the U.S. relative productivity figure at one-third that of Japan, the recognized leader in shipyard productivity (Frankel, 1996). The findings common to all of the recent studies is that U.S. shipyards' labor productivity and relative level of applied technology are lagging foreign competition.

The answer to the competitiveness problem, then, should be a strong *determination to be competitive*, the acquisition and *application of the appropriate technology*, and the *integration of new technology* throughout the company, not just the haphazard add-on of technology, as is often the case. And, while the formula is simply stated, carrying it out involves a very difficult adjustment.

CHALLENGES

With the end of the Cold War, the reduction in defense spending, and the downsizing of the U.S. Navy fleet to 340 ships, large, private U.S. shipyards face the major challenge of entering the worldwide commercial shipbuilding market. Their survival is at stake. The number of new U.S. Navy ship contracts in the foreseeable future will not sustain more than three or four large shipyards, so the rest must enter commercial shipbuilding as their primary source of revenue or go out of business.

No industry in a position similar to that of U.S. shipbuilders has become internationally competitive in less than 5-10 years. Foreign builders have captured the lion's share of new construction, but as the market grows, U.S. shipbuilders have a chance to regain some of the market share lost in the 1980s and early 1990s. U.S. shipbuilders would like to hold three to five percent of the world's market and can do so if they streamline their operations, make significant capital investments, and adopt process improvements to raise productivity. U.S. shipbuilders face challenges in the areas of finance, technology, labor, and management.

Finances

If U.S. shipbuilders want to be competitive in the international commercial market, they must change their fiscal modus operandi. As a start, they will have to adopt a commercially oriented accounting system. Currently, government cost-accounting requirements are far more numerous, complicated, and manpower intensive than those required in commercial shipbuilding. To perform commercial work, the shipyards need to significantly reduce their large documentation and accounting teams.

The next fiscal step in helping U.S. shipbuilders make the transition to the commercial marketplace is to wean private shipyards from the generous financing and payment practices of U.S. Navy shipbuilding contracts. These practices are a major reason why U.S. shipyards are not competitive in the international commercial marketplace. For example, progress payments on Navy shipbuilding contracts are so favorable that private shipyards have little or no need to raise private financing for the working capital to fund their investment during ship construction. In all practicality, a Navy shipbuilding contract allows a company's cash outflows to be covered by biweekly cash inflows. Such practices are unheard of in the commercial shipbuilding market.

Those shipyards already in or planning to enter the commercial shipbuilding arena face another challenge: the loss of government subsidies. The Organization for Economic Cooperation and Development (OECD) agreement developed jointly in 1994 by the major shipbuilding nations seeks to remove unfair advantages and level the playing field for worldwide competition. Part of the agreement reduces financing limits on Title XI loan guarantees, a financial program that has recently helped U.S. shipyards to make sales in the commercial marketplace. Even though there is a great deal of controversy over its details and its impact on U.S. shipbuilders, the OECD agreement provides significant competitive advantages by eliminating extensive foreign government subsidies.

Technology

In order to be profitable in the international commercial shipbuilding market, U.S. shipbuilders must overcome the technological advantage enjoyed by foreign competitors. *Their challenge is to choose the right new technologies to recapitalize the U.S. shipbuilding industry.*

Many of the shipyards we visited in Europe have developed construction/assembly techniques that use new technologies to modularize the shipbuilding process and have redesigned their shipyard infrastructures. The new technologies include state-of-the-art computer-assisted design and computer-assisted manufacturing systems for the design, installation, and future maintenance of ship hulls, modules, and systems.

Other European process technology studies netted improvements in sheet metal, furniture, electrical (conduits/cable), and communications installation operations. U.S. and European shipyards differ greatly in this area (Storch, Clark, and Lamb, 1995). Foreign shipbuilders concentrate on perfecting methods of ship design, steelwork, outfit drawing preparation, production design, and project planning before assessing the need for computers to support them. In particular, the Norwegians have significantly reduced their production times and costs by improving processes. They are considered to be "best-in-class" for modularization and other production processes.

In addition, Norwegian shipbuilders are particularly successful in ergonomically planning the yards themselves. They consider the space needs of the fabricators, installers, and assemblers involved in the production process and make significant investments in process improvement techniques. Their finely tuned yard layouts (infrastructure) are fully integrated with their production methods, which results in cost benefits in processes such as fabrication, welding, grinding, painting, and fit-up.

Another window of opportunity for the United States is advances in ship design. Applying new technologies to hull design and propulsion systems can lead to the higher speeds being demanded by the shipping industry. One U.S. firm, FASTSHIP, has developed an 850-foot fast freighter that

will cut in half the average time to cross the Atlantic. The competitive advantage that this new ship design can yield could be a major breakthrough for U.S. shipyards. Unfortunately, because of a lack of competitiveness among U.S. shipbuilders, the first ship of this type will most likely be built in Europe.

Management

Astute action by management can bring success to the U.S. shipbuilding industry, and today's environment is ripe with opportunity. First, management must streamline the industry by removing burdensome layers within organizations and reducing engineering and administrative staffs. Most of the yards we visited in Europe employed very few people in administration and engineering. Excessive government administrative procedures need to be cut from Navy contracts. The industry must improve its processes and create a sleek industrial base that has the flexibility to quickly adapt to changes in technology.

Second, U.S. shipbuilders must refocus their attention on their labor force. Talented employees should be recruited, trained, nurtured, and given permanent positions in the organization. If the workers are productive and protected, they will work harder and be more willing to make recommendations on efficiency and alternative market opportunities. Finally, shipbuilders must aggressively market their companies. If prices can be made competitive, then success depends primarily on the aggressiveness of U.S. firms in pursuing new customers.

Labor

Productivity is a critical element in the recovery of U.S. shipbuilders. No method used to compare foreign and U.S. shipyards yields pure results, but by any measure foreign shipbuilders certainly use fewer workers in the aggregate. Furthermore, foreign shipyard workers are capable of a greater variety of tasks than their counterparts in U.S. shipyards are. For example, most European welders can weld with multiple metals using multiple methods while U.S. welders tend to be more specialized and limited in scope.

In addition, foreign shipyards have developed a well-trained, motivated, and flexible labor force that communicates openly--from the lowest levels on the shop floor to the highest levels of management. The workers are also committed to an aggressive cross-training program that includes team-oriented assignments to improve process efficiency.

OUTLOOK

Military Shipbuilding

The Navy recently accelerated its shipbuilding delivery schedule, but few if any ships are being added to new-order books. That cost is still the major driving factor is no surprise given the price tag of a major naval ship. The newest attack submarine, for example, will cost over $1.5 billion.

The current and projected Navy requirements of six to seven ships per year will not be sufficient to keep the existing number of commercial Navy shipbuilders in business. Some yards will close or turn to the ship conversion and repair business only. For example, once the current backlog of TRIDENT and SEAWOLF submarines is finished, General Dynamics's Electric Boat Division in Groton, Connecticut, can expect no new orders for submarines for several years until the next-generation attack submarine is designed and the contract(s) to build them are awarded.

Commercial Shipbuilding

The commercial shipbuilding forecast looks promising compared with that for naval shipbuilding. Estimates indicate that there will be a sizable demand for new commercial ships over the next three to five years because the commercial fleet is very old: by the mid-1990s, the average age of a commercial ship will be approximately 25 years.

The greatest need for ships will be in the tanker market. Additionally, while the trend is to build bigger ships, there is a strong market for handysize/handymax ships (between 20,000 and 50,000 dwt). Changes in environmental law, primarily in the United States, are affecting demand for new double-hull tankers. Other nations may follow suit--

especially in light of the recent supertanker grounding and oil spill off the coast of Wales.

Experts in the shipbuilding market forecasting business, such as A&P Appledore International of the United Kingdom and Drewry Shipping Consultants of London, agree that for the United States to have any hope of improving its share of the commercial market, it must enter a segment that complements its naval shipbuilding expertise, such as complex-type liquid natural gas (LNG) carriers and cruise ships. However, the overall world market for complex ships is small and dominated by European shipbuilders. Price, quality, and the ability to meet an agreed-upon delivery deadline will continue to be key factors in the award of shipbuilding contracts.

Labor

Right sizing has meant massive layoffs for all U.S. shipyards, and the industry is becoming increasingly concerned that the pool of manpower with critical skills is aging, that workers are paid poorly, and that the industry is too unstable to attract new workers.

According to the U.S. Bureau of Labor Statistics, U.S. labor rates are extremely competitive compared with those in European countries (Figure 3).

Figure 3

Relative Shipyard Labor Rates in 1993 U.S. Dollar Equivalents Costs (incl. overhead & benefits)

South Korea	0.64
United States	1.00
Denmark	1.33
Japan	1.35
Germany	1.36

However, the *productivity* shipbuilders receive for the labor rates still places U.S. shipyards at a distinct disadvantage. U.S. shipyard workers can compete globally if they are properly trained and supported with the right technology. Clearly, there must be more layoffs, aggressive outsourcing, and wholesale retraining for this work force to be effective. Shipbuilders in Europe and the Far East produce excellent ships, on time and on cost, with integrated technology that uses much smaller labor forces.

Is a High-Technology Yard Enough?

In simple terms, absent the business commitment to become globally competitive on the commercial shipbuilding scene, no amount of technology will be enough. Assuming the commitment is there, obtaining and applying the appropriate process and hardware technology is necessary.

Globalization has the effect of flooding the shipbuilding industry with revolutionary advances in hardware and process, such as the use of robotics and unit-construction techniques. The pace of innovations and advances in engineering, design, hardware, and process is incessant--and certainly not advantageous to a U.S. industry that has not been a competitive player for the past 15 years and is not familiar with the potential of those advances.

Assessment

The current U.S. capacity to build and repair ships can support the national security resource requirements for the short term (1-5 years) under the scenario that assumes two major regional conflicts. This capacity includes support for the construction of orders and projected orders for Navy combatants, auxiliaries, and strategic sealift vessels, both new construction and commercial ship conversion--a more cost-effective alternative. Current capacity can support full surge and sustainment as delineated in the latest *Mobility Requirements Study Bottom-Up Review Update*. In the long term (5-25 years), the projections indicate that even if the shipbuilding capacity further shrinks to five major building yards, capacity will be sufficient to produce the

number of new platforms necessary to replace the existing Navy fleet of more than 300 ships.

The greatest impediment to increasing the U.S. market share in commercial ship construction is that large U.S. shipyards are not globally competitive. To a large measure this has resulted from a conscious decision by the shipyards to dedicate their resources to the significantly more lucrative market of U.S. Navy work. The prospect of winning future government contracts has a paralyzing effect on the business decisions necessary for global, commercial competitiveness. And the current billion-dollar backlog of government ship orders with many of the first-tier shipyards only serves to bolster their reluctance to pursue global competitive status.

The current domestic political and economic climate will not tolerate significant new subsidies to support private shipyards that are not globally competitive. The U.S. market share of commercial vessel construction will increase only as a result of the competitive will and determination of individual shipyards. Competitiveness cannot be mandated by the government; it can be realized only through sound business decisions, determination, and patience.

GOVERNMENT GOALS AND ROLE

Historically, different administrations and Congresses have tried to boost business in U.S. shipyards by providing everything from tariffs to direct subsidies. The purpose of their intervention was to lower overhead costs assigned to Navy ships and to ensure that a shipbuilding industrial base is maintained in the country.

National Security Surge and Mobilization Requirements

The nature of today's threat has changed from global challenges to more specific regional conflicts. Supporting conflicts of short duration with a "get-in-and-get-out" mentality is the only scenario that seems consistent with the limits of U.S. public resolve. If in the future the United States is faced with a national security threat that requires mobilization assets, the U.S. military will make use of the current active U.S. Navy fleet and the U.S. Maritime Administration's Ready Reserve

Fleet prior to trying to build new sealift vessels. In addition, the Department of Defense (DoD) and the Department of Transportation are investigating innovative methods of integrating the commercial maritime sector's vessels into sealift mobilization.

As a result of lessons learned during Desert Storm, the RRF has remained about the same size (95 ships), the number of roll-on/roll-off ships has increased modestly, and *the readiness of the entire fleet has increased significantly*. The RRF improved its readiness by placing minimal crews on high-value ships to expedite turnaround and by increasing funding for maintenance and repair. With the move toward come-as-you-are conflicts and the response capabilities of the RRF, *the limited abilities of U.S. yards to surge will not be significant* in real-time mobilization efforts.

Survival of the Shipbuilding Industry–Government Efforts

If the industry takes no progressive action, a minimum number of naval shipbuilders will remain viable, probably through mergers, joint ventures, or both. *The federal government should allow these consolidations to occur. In addition, naval shipyards in the ship repair, vice shipbuilding, business should be transferred to the private sector and operated as government-owned, contractor-operated (GOCO) facilities.* President Clinton and the U.S. Air Force used this strategy to reduce the number of aircraft repair depots when faced with the 1995 Base Realignment and Closure Commission proposed closings. By making the former naval yards available as GOCO facilities, the government would ensures that they will be available in times of extended national emergency, yet personnel and infrastructure costs during peacetime will be greatly reduced.

With the reduction in demand for U.S. military ships, large U.S. shipyards face a new challenge--transferring their skills and technologies from the military to the commercial market. *As long as U.S. shipbuilders can continue to construct high-technology replacement vessels to maintain the U.S. fleet at the required level, then encouragement, vice subsidized funding, is the desired means by which the U.S. government should contribute to the strengthening of shipbuilding in the United States.*

President Clinton's 1993 National Shipbuilding Initiative (*Strengthening America's Shipyards: A Plan for Competing in the International Market*) contains cooperative research and development (R&D) projects (MARITECH) that have assisted three of the largest U.S. shipbuilders in designing LNG carriers and cruise ships. This effort is entirely consistent with the niche markets the U.S. shipbuilders should enter and will help them compete with builders internationally. *The MARITECH program should be continued and expanded consistent with provisions of the OECD agreement and the industry's needs.*

The administration is using existing organizations (e.g., MARAD, the U.S. Foreign Commercial Service, and U.S. embassy personnel) to assist shipyards in their international marketing efforts and to facilitate cooperative arrangements and alliances between U.S. and foreign yards. MARAD, which is focusing on educating U.S. embassies on the needs of U.S. shipyards, is helping U.S. shipbuilders make contact with embassy personnel around the world who can provide information concerning potential international shipbuilding opportunities. MARAD is coordinating workshops, seminars, and trade exhibits with industry on marketing techniques and productivity improvements. *These efforts should be continued.*

In the Clinton plan, government agencies, including the DoD, the U.S. Coast Guard, and the Occupational Safety and Health Administration (OSHA), were assigned the task of eliminating unnecessary government regulations. Companies that do both commercial and government work are often forced to segregate military and commercial business to enable them to keep track of and ensure their compliance with government contract regulations. According to industry, the most important step the federal government could take is to remove requirements imposed only on federal contractors. Industries could then meld commercial business practices and projects with military-specific projects. The DoD has already taken steps to move away from military-unique specifications.

OSHA held extensive meetings and workshops with labor and industry representatives to develop streamlined regulations and "user-friendly" compliance instructions for commercial shipyards. The U.S. Coast Guard is working with the International Maritime Organization to

upgrade international standards to more closely match the stringent safety requirements enforced on U.S. vessels. In addition, the Coast Guard is working with U.S. carriers and standards bodies to revise or eliminate regulations that do not affect vessel safety yet add unnecessary costs. *The efforts toward regulatory streamlining and reform in all applicable federal agencies should be continued and expedited.*

Other actions that should be taken to support U.S. shipbuilding include (1) instituting tax reforms to promote commercial investment in production R&D and infrastructure improvements (an industrywide issue), (2) promoting technology sharing within and between industries, (3) using defense R&D to enhance productivity in naval construction (a cost-cutting measure), and (4) giving incentives for reducing the cost of naval construction by rewarding on-time, under-cost performances. Finally, the federal government should make every effort to pass the OECD agreement and, once it is in effect, diligently penalize signatory countries who do not comply with it.

CONCLUSIONS

The United States is no longer a world-class commercial maritime nation, nor is it a leader in the building of oceangoing vessels. The periods of glory to which the United States points with pride were merely aberrations embarked upon to support the nation at war. Since World War II the U.S. shipbuilding industry has emphasized the building of warships for the military departments. The shipyards staked their futures on U.S. government business, and this affiliation proved to be costly.

Certainly, before the current military drawdown, there was adequate money to support numerous shipyards. Now, because of the drawdown, the United States is losing 10-15 percent of its "large-vessel-capable" yards annually. The loss will likely continue unchecked until what remains is only the number of first-tier yards that can survive under the minimum new-build scenario for the U.S. Navy now in effect. Repair shipyards and second-tier shipyards have fared much better and will continue to compete nationally and internationally.

U.S. shipyards' survival, therefore, depends on their viability in the global commercial market. U.S. shipyards are ill-suited for this competition for several reasons. First, although they retain more than adequate physical plants, the yards are old and have not been materially improved since World War II. In general, the only upgrades made to plant equipment have been government financed. By comparison, foreign yards have modernized and build with state-of-the-art equipment.

Second, U.S. shipyards have focused little engineering effort on the improvement of manufacturing processes. Shipbuilding productivity can be improved if the vast pool of engineering talent is applied to manufacturing operations.

Finally, to regain a dignified market share, U.S. shipyards must find the right niche in the commercial market to take full advantage of current opportunities and their own greatest talents. Cruise ships and special commodity carriers are examples of market niches to consider.

Most important, shipyards in the United States are still adequate to meet current and projected national security needs, but that is only part of the story. Tremendous amounts of capital are required to bring the yards back to cost-efficient production. Sources used in the past are no longer available, so improvements must come from profits generated in the global, commercial shipbuilding markets.

Succinctly, the first-tier shipbuilding industry in the United States is in significant trouble. Without a metamorphosis, large shipyards will die and leave the United States without any large shipbuilding capability except that protected for military purposes. Second-tier shipbuilders and repair yards will continue to compete successfully in both the domestic and international arenas.

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SPACE INDUSTRY STUDY REPORT 1996

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ABSTRACT

This study examines the potential for the United States to privatize and commercialize selected aspects of the space industry to ensure continued U.S. global dominance of space in an increasingly competitive international marketplace. With well-defined and culturally appropriate visions and plans, other nations have successfully leveraged government and industry partnerships to forge world-class firms and satisfy their national interests. The United States should do the same.

This report examines four sectors of the U.S. space industry--launch, satellites, satellite operations, and applications--and selectively compares them with the space industries in India and Japan. We conclude that the United States could greatly improve its international competitiveness, as well as reduce government space expenditures, by transferring selected segments of the government space industry to the commercial sector.

> *I believe that there are moments in history when challenges occur of such a compelling nature that to miss them is to miss the whole meaning of an epoch. Space is such a challenge.*
> --James A. Michener

> *There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We must be second to none in the applications of advanced technologies to the real problems of man and society.*
> --Vikram A. Sarabhai, India Space Program, 1962

INTRODUCTION

Contrary to popular thinking, the space industry did not start with the 1957 Sputnik launch. Although that event galvanized the United States to mobilize for the space race, the roots of the space industry go much further back and are truly international in nature. The first recorded use of rockets occurred in 1232 AD, when the Chinese used a rocket during a siege of the South China city of Kai-Fung-Fu by the Mongol hordes led by Ogdai, son of Genghis Khan. The fledgling rocketry industry grew slowly, culminating in the modern space age, which began on March 16, 1926,

when Robert Goddard launched a small liquid-fueled rocket for a short but tremendously significant flight.

The space industry has evolved in interrelated yet distinct interactions among four major sectors--launch vehicles, satellites, satellite operations, and applications--for which sales approach $70 billion a year. Although initially supported completely by the government, commercial space today is rapidly growing and will soon command a sales majority. Of this growing enterprise, foreign entities have already cornered over 60 percent of the market.

Our study's purpose was to examine the U.S. potential to privatize and commercialize selected aspects of U.S. government space systems to ensure the continued U.S. global dominance of space in an increasingly competitive international marketplace. We examined the four sectors of the U.S. space industry and selectively compared them with corresponding space industry sectors in India and Japan.

The methodology of this study included individual student research, visiting lecturers and expert panelists, international travel for group research, and visits to domestic firms and government agencies representing the four space industry sectors. Facility tours, briefings, and discussion sessions focused on profitability and productivity trends, capital investment and return on investment, business expansion potential, research and development (R&D), industry downsizing and consolidation, production capacity (surge and mobilization), core competencies, political and social factors (management, work force, culture), and the role of the government.

THE SPACE INDUSTRY DEFINED

The space industry is a set of diverse companies and government agencies, interconnected as suppliers and market, that produce a wide range of space-related products and services for government, civil, and commercial entities. The "industry" comprises a number of interrelated activities: launch system development and manufacturing, satellite development and manufacturing, the supporting infrastructure, applications data processing, and the development and manufacturing of user equipment.

The U.S. space industry has traditionally been a virtual *oligopoly*--the government was the only significant buyer, the number of suppliers was limited, and the entry costs were and still remain very high. Today, however, commercial corporations are exerting increasing influence as they become buyers as well.

The space industry is *interdisciplinary*--it synthesizes fields as diverse as aeronautical engineering, materials science, high-energy chemistry, antenna engineering, radiation physics, and computer science. Within this vast assemblage of high-technology systems, the space industry is divided into four interconnected yet diverse sectors: *space launch, satellites, satellite operations, and applications.*

Space Launch

U.S. launch systems are based on 1950s and 1960s intercontinental ballistic missile designs. Each U.S. launch is a unique *technology demonstration* since launch vehicles are specially tailored for each satellite. More recently, U.S. productivity has increased as a result of quality improvements, the push for standardization, and improved management practices. However, some foreign space programs now have an advantage over the U.S. program because they use a more disciplined and standardized approach and have incorporated more current technology in their systems.

Satellites

Satellite development and production, which uses mostly U.S.-sourced, high-technology components, involves high unit costs, low production volumes, and long production flow times. Government quality and reliability standards are highly demanding parameters, but commercial standards are increasingly meeting or exceeding them. Recently, government satellite development has been plagued by discontinuous production, outdated processes and manufacturing technologies, critical foreign dependence, and reliance on parts and components that are either obsolete or have limited availability. Commercial satellite production is

moving to efficient, production-line manufacturing that is extremely responsive to market forces.

Satellite Operations

Satellite operations ensure successful satellite deployment by means of launch and early-orbit operations, monitor and maintain the day-to-day health and status of spacecraft on orbit, and manage specific mission payload operations on each satellite. The operations vary widely depending on whether the satellite is a one-of-a-kind defense mission or a one-of-many commercial satellite.

Applications

Space applications, whether commercial or military, can be defined as the products and services provided by space assets. While these products and services are either collected (e.g., imagery) or transmitted (e.g., telecommunications) by satellites in orbit, the vast potential commercial opportunities for space applications lie in the exploitation of these data for defense or for the general well-being of the nation.

Commercial space systems are currently producing military-quality products and services, and the Department of Defense (DoD) is buying them. Examples of civil space applications are global broadcast, mapping, search and rescue, disaster warning, and comprehensive resource management and planning. The DOD′ s requirements are generally summarized as the areas of communications, surveillance and reconnaissance, navigation, meteorology, and space R&D.

CURRENT CONDITIONS

Space Launch

Orders and sales of U.S. military space-launch systems declined from $5.9 billion in 1990 to $4.4 billion in 1994; during the same period, the total *nearly doubled* for the U.S. nonmilitary sector, increasing from $2.8 billion to over $4 billion. French, Russian, and Chinese launch systems

have captured 60 percent of the global commercial market for medium-launch vehicles.

The major U.S. space-launch firms, Lockheed Martin and McDonnell Douglas, were exceptionally successful and profitable in 1995. Launch sales accounted for approximately 29 percent of Lockheed Martin's and 14 percent of McDonnell Douglas's profits in 1995. Overall, sales and profits increased during the last quarter of 1995 for larger, upper-tier firms while those for smaller, lower-tier supplier firms declined slightly. The average profit margin industrywide was 10.5 percent for the year.

The world launch forecast is for at least 30 launches annually (1995-2010), the majority in the medium-launch vehicle range. No single supplier has the capacity to produce that many satellites of that size. In contrast, the immature market for small-launch vehicles has an overcapacity of potential suppliers. Many companies attempting to enter small launch found 1995 profitable but have yet to prove a mature capability in the global marketplace.

The launch sector is primarily dual use, and technologies are the same or similar for both commercial and defense systems. The U.S. subsidizes such industry activities as the operation and maintenance of government-owned launch facilities, range instrumentation, and infrastructure at the two U.S. launch sites: Cape Canaveral, Florida, and Vandenburg, California. When the government opens its facilities for launches, it requires only that commercial customers pay specific charges associated with a particular launch.

No quotas are directly imposed on the industry, but some restrictions exist on the export of launch vehicle technology. Calls for protectionism come from commercial Spaceport authorities at each launch site, who maintain that U.S. commercial launches should be conducted at their facilities, and from commercial industries, who propose limiting foreign launches of U.S. satellite systems. For example, the space industry objects to U.S. government approval for Ukrainian and Russian vehicle launches of commercial U.S. spacecraft.

Satellites

The global commercial spacecraft market has an overcapacity of suppliers and six primary U.S. competitors: Japan, France, Russia, India, China, and Israel. Leading domestic satellite developers include Lockheed Martin, TRW, GM-Hughes, and Loral Space Systems. Spacecraft integration is a U.S. core competency. The world market wants U.S. technology, as characterized by "international cooperation," the term commonly used to describe a foreign country's desire for U.S. technology. Business flows two ways: the United States buys satellite components and sensors from foreign sources, and other nations buy heavily from U.S. sources. As beneficial as this may be for the balance of trade, the downside for national security is that U.S. production depends on foreign sources for some critical items, such as space-qualified batteries. Foreign dependence may be controlled but not eliminated.

The DoD satellites now on orbit exceed their projected design lifetimes; the large backlogs of space assets have resulted in fewer new system starts. The corresponding erosion of engineering capability in the industry is a serious concern. Government labs and development organizations perform more of the R&D previously done by industry; National Aeronautics and Space Administration (NASA) centers and DoD labs do some spacecraft integration tasks in competition with industry. In the past, government centers and labs worked *with* industry to fulfill critical technology requirements. Recently, industrial funding of the government lab infrastructure has forced labs into more direct competition with their support industry. This raises questions about the roles of government labs in spacecraft-building functions other than fundamental science--which might be better done commercially.

Although U.S. satellite firms operate with little foreign competition for DoD, NASA, or commercial payloads, reductions in the DoD satellite budget suggest leaner times ahead. Budget projections for DoD satellite production show a significant reduction from 1996 to 1999 (mostly resulting from backlogged assets awaiting flyout)--16 percent from 1994 to 1999 and from a $2.1 billion high in 1995 to an estimated $600 million in 1998. The industrywide trend is toward medium-sized spacecraft,

although some large and small satellites will be retained. Advances in space components miniaturization mean *more capability* vice smaller size.

Most traditional DoD spacecraft and payload prime contractors are in financially viable positions. Lower-tier firms are merging with primes, going out of business, or exiting defense for commercial markets.

Capital investments peaked in 1991 and have declined since--a trend of major concern. Failure to invest in R&D and new equipment, coupled with the loss of skilled designers, will weaken the industry's ability to introduce new technology unless specific action is taken to reverse this trend.

Defense cutbacks directly affect the critical skills of the satellite industry's work force. Because many displaced workers are disinclined to return to the unstable aerospace workplace, their many critical skills will be lost to the industrial base. It takes two to five years to reconstitute the critical engineering and technical skills lost. The booming commercial satellite market provides stability for skills used in both the commercial and defense industries, but defense-specific technologies may have very cold production base if the United States attempts mobilization or reconstitution in the future.

The current condition of the satellite market reflects of the absence of a coherent national space policy. In lieu of such a policy, market forces are the only stimulus for the industry's current condition. A plan that balances free-market support and government responsibility is essential. The government cannot be in the business of picking winners and losers in the space industry but can ensure that all U.S. firms get a fair chance to compete internationally and domestically.

Satellite Operations

Command and control (C^2) of spacecraft on orbit was pioneered by the U.S. government as an engineering-dominated activity. Technical experts manned consoles 24 hours a day to ensure a rapid response to satellite problems. The government still uses this approach, resulting in high personnel overhead. This slow evolution in satellite operations results in

cumbersome, expensive, and outdated hardware and software systems support. In contrast, commercial satellite ventures employ more automated and modern data systems and minimal staff.

Industry leaders in satellite operations include Lockheed Martin, TRW, and Loral Space Systems. The sector is a niche market at best. Lockheed Martin has had measured success marketing operations support services, but this support is often bundled with spacecraft development in the commercial market and sold to foreign governments and commercial customers as a package.

Applications

Some of the most profound space applications are the direct result of recent government deregulation that allowed commercial 1 meter (m) resolution remote sensing, or imagery, satellites and thereby immediately caused an explosion of activity in the U.S. commercial sector. Five firms already hold licenses to operate 1-3 m systems before 2000, and the first will launch a 3 m satellite in 1996. The expected market is over $10 billion in annual sales of imagery and geographic information systems. Another application resulting from deregulation is the global positioning system (GPS). The decision by the government to allow commercial access to previously classified parameters has driven the value of the GPS market from $80 million in 1990, to $1.2 billion in 1996, to a forecast of over $8 billion by 2000.

U.S. civil and commercial remote-sensing capabilities currently consist of Landsat, first launched in 1973. Landsat multispectral (30 m) data, the best U.S. nonmilitary imagery available, is used worldwide. France operates the superior SPOT remote-sensing system (10 m resolution imagery). The DoD annually buys commercial imagery from both Landsat and SPOT and leases deployable SPOT ground stations.

India has taken the world lead in the civil/commercial "resolution race" with its IRS-C satellite, which collects 6 m resolution imagery. India has also established an effective, extensive system to distribute applications to all government agencies and the private sector with the goal of improving national well-being through the direct application of satellite-derived

products and services. Japan has also entered the remote-sensing market in ground stations and satellites. These international developments clearly demonstrate the need for the United States to develop a vision, strategy, and policy for space.

CHALLENGES

Space Launch

The key challenges in space launch are to improve responsiveness and reduce costs while maintaining high reliability. The heritage of the U.S. space-launch infrastructure is that of a R&D environment. Although the U.S. capability is relatively reliable, each launch is slightly different, and economies of scale are not and cannot be achieved. Lack of standardization and interoperability significantly increase the time lines and costs of launch preparation.

We estimate that *the United States must decrease its costs for launch and launch operations by one-third to one-half* to be competitive in the evolving international commercial launch market. The U.S. government has attempted to reduce launch costs by embarking on several new launch programs since the 1980s, but in each of the first three attempts programs were canceled because of excessive cost growth. The most recent program, the Evolved Expendable Launch Vehicle (EELV), whose design was primarily driven by cost, appears to be on track. We expect that developers will use EELV technology for commercial sales. In addition, the Reusable Launch Vehicle (RLV) technologies also show promise for the next-generation launch vehicle.

Satellites

There are currently four major prime contractors for domestic satellites: Lockheed Martin, TRW, GM-Hughes, and Loral Space Systems. Despite layoffs (and loss of critical skills), the primes' financial positions are stronger than during any recent period. According to the U.S. Air Force Industrial Base Assessment, satellite primes and major subcontractors are considered to be in a better position than lower-tier contractors because of their flexibility and capability for vertical integration--pulling lower-tier

work in-house to counteract temporary drops in sales or losses (Manufacturing Technology Directorate, 1993). The satellite industry will most likely continue downsizing and consolidating, but the nation must protect its technology and not treat it as a commodity to be sold.

Mounting debt incurred by U.S. firms as the space industry consolidates--with resultant high debt-to-equity ratios--may limit their ability to compete internationally. Analysts speculate that Lockheed Martin will pay for its purchase of most of Loral Corp. by increasing the firm's debt, raising Lockheed Martin to 179 percent equity, up from 64 percent in 1990; ideal levels for the industry are 70-100 percent. Analysts maintain that as business shifts increasingly to global markets, firms must invest in modifications to suit new customer requirements. Firms with high debt levels lack the flexibility to take action, and high debt ratios pressure firms to cut costs and prevent spending on expensive projects with high-risk payoffs. Because return on investment is time dependent, this also translates to cuts in R&D funding.

Critical Technologies and the Industrial Base

The space industrial base requires numerous critical skills, processes, facilities, equipment, and technologies. Satellite development requires high-technology engineering, materials, and processes, and satisfactory production requires the development of proprietary processes and highly trained engineers and specialists with distinctive skills. Defense budget cuts could significantly affect U.S. satellite production capabilities. Trends are toward loss of multiple sources for space-qualified parts and materials and sole sources for high-technology parts and materials.

Government Procurement Practices

Advocates of dual-use technologies assert they provide opportunities for large and small firms to offset business losses caused by a declining defense budget. However, most individuals interviewed said that there is evidence neither of government policy or money spent on incentives nor of contracts awarded as a result of any dual-use technology program. Many firms have decided to forgo government contracting rather than continue to absorb the cost of compliance with government contracting standards.

The DoD policy requiring firms to separate government and commercial production lines exacerbates the problem. Integrated military and civil production could give firms the incentive to maintain DoD capabilities or develop expensive, risky new ones.

Satellite Operations

The primary challenges in this area are to streamline the government infrastructure for satellite operations and incorporate more modern hardware and software systems for satellite C^2. Obstacles to achieving these goals are change-resistant, bureaucratic organizational equity, protectionism within the government, and limited funds for major C^2 system upgrades in an austere federal budget environment. Teaming with commercial firms, outsourcing to them, or both could yield substantial benefits to the government.

Applications

The government's deregulation of telecommunications, GPS, and imagery has opened the door to the interdisciplinary commercial market, which contains an array of products and services that will yield a profitable return on investment. Global and domestic firms seek control of all market sectors--space, data processing, and product distribution--through "international cooperation" and partnerships. The commercial sector's challenge is to be the first on the market with a total system package. The firm that first combines a constellation of high-resolution (up to 1 m) imaging satellites with ground control, data control, and services will gain a predominant market share.

Other nations recognize the potential to gain national power and prestige from successful, world-class space programs. Many countries--some that may someday be U.S. adversaries--could operate satellite systems on a par with the that of United States. As a result, the U.S. government must reexamine the full spectrum of doctrine, policy, and strategy. Future military and diplomatic operations must be conducted under the assumption that all potential adversaries possess 1 m visibility into U.S.

activities as well as an array of broadcast and communication satellites (comsats). National security implications are also clear--the United States would have to request precrisis imagery of an area, and that request could easily be denied.

OUTLOOK

The next few years should mark a turning point for the space industry. The market is fast changing from one of reliance on national space programs and international consortia to one driven by private industry. Traditional space companies, like Lockheed Martin and Orbital Sciences, are also moving to provide satellite-based services.

Another trend in the space industry is that the competitive desirability of offering customers one-stop, turnkey operations is encouraging corporate mergers, acquisitions, and joint ventures. The overall effect will be to reduce even further the number of space prime contractors.

Space prime manufacturers are consolidating as the market expands. Normally, this trend would reflect overcapacity within an industry, but in this case it means that firms are anticipating a large and diverse space market and positioning themselves to take advantage of as many market segments as possible.

Space Launch

In general, the space-launch sector can support national security requirements in the short term with excess capacity and high costs. The major shortfall remains in procedural turnaround time. Over the long term, the nation will be unable to meet its national security needs without EELV.

The launch infrastructure is adequate for national security needs, but its technology needs modernization. Modernizing the infrastructure would improve the on-pad processing of boosters and payload integration for some spacecraft, which would in turn improve surge and mobilization capabilities. An important point to remember, though, is that launches must be reliable. While space launch is expensive, its percentage cost is

much less than that of satellites or the product delivered from those satellites.

The production of launch vehicles now follows a pseudo "just-in-time" schedule: they are produced slightly in advance of specific launch manifests. The schedule is considered "pseudo" because the DoD has in reserve at least one type of every booster needed to launch one of its satellites. Space-launch mobilization takes the form of "outprioritizing" launch customers already on the manifest and "using" their boosters until production is increased to meet the demand.

Payload availability is another key ingredient in space-launch surge and mobilization. Satellite industry moves toward a standard interface with boosters will enable flexibility in establishing launch manifests.

The industry is also moving toward space-launch standards. As a result, the DoD will have to use standard commercial launch specifications in the future. A recent Air Force Scientific Advisory Board study recommended that the government use commercial launch services for *most* military satellites (U.S. Air Force Scientific Advisory Board, 1995). This policy shift would boost the commercial sector and allow government funds to focus on R&D instead of on launch and operations infrastructure. It is this support, however, that the United States provides on a subsidized basis to commercial customers. The U.S. ELV market is facing fierce competition from the European Space Agency, Russia, Ukraine, and China. The success of U.S. commercial launch will depend on continuing a general U.S. policy preference for using U.S. launchers for U.S. payloads. Obviously, NASA's use of commercial launch services and DoD-funded launches would greatly offset an imbalance in U.S.-negotiated launch allocations with other countries.

The trend toward small satellites using lightweight launchers may not be as pronounced as originally anticipated. The use of multiple-manifested satellites on large boosters may prove to be the most cost-effective means of launching the planned large constellations of small, commercial satellites.

Finally, future surge and mobilization capabilities will be improved by the ELV and RLV programs. If booster life-cycle costs are reduced by 50 percent as predicted, the industry may be able to afford to stockpile key common components, making mobilization much easier. Sharing production lines will also make surge much more realistic.

Spacecraft

The expansion of the space industry will continue to be driven largely by growth in demand for a wide variety of telecommunications. Spacecraft technology has evolved to the point where it is commercially feasible to offer satellite-based communications services. Satellites, though smaller, are now technically more advanced and powerful than before, allowing a wider range of applications.

About half of the 1,000 satellites scheduled for launch worldwide through 2000 will be small (less than 500 pounds), low-earth-orbiting (LEO) mobile comsats. Most will belong to multisatellite systems such as Motorola's Iridium or Orbital Sciences' Orbcomm. Also planned are medium Earth-orbiting mobile systems using slightly larger satellites, such as ICO Global Communications' Inmarsat-P. About 10 percent of the comsats will be larger, geosynchronous orbiters offering advanced, fixed services such as direct-broadcast TV. The most common geosynchronous satellites should continue to be traditional telecommunications and TV broadcast satellites for national systems, such as Japan Satellite Systems' JCSat.

One proposed comsat system, Teledesic, could radically alter all current projections for the future space market. Its ambitious network plan--800 active LEO satellites--would dwarf currently planned systems such as Iridium (66 satellites) in size and cost.

To a lesser extent than that for telecommunications, the nascent market for commercial Earth imaging also drives industry expansion. The loss of Landsat 6 in 1993 and subsequent concern over the U.S. capacity for Earth imaging highlighted a need--and the potential for large profits--within the market. A recent U.S. policy allowing the commercialization of high-resolution imagery fueled the interest of firms such as Lockheed-

Martin, Orbital Sciences, and Ball Aerospace/WorldView Imaging. Along with government-sponsored programs such as NASA's Earth Observing System, Japan's ADEOS, and India's IRS, about 50 Earth-imaging satellites are planned for launch through 2000. These larger satellites mean an ongoing need for at least medium-lift launch capacity.

The range of promising opportunities for growth in satellite-based businesses worldwide will enable top- and middle-tier firms to focus on the satellite business and its excellent growth potential. There is room for several successful, high-quality organizations with different technologies serving different sectors of the market.

Satellite Operations

In the satellite operations sector, industry has correctly reacted to and outpaced the government in efficiency improvements. The government has begun taking steps to streamline and update its satellite operations, but the organizational infrastructure has so much inertia and the costs of reengineering entire hardware and software systems are so massive that any significant changes are unlikely for several years.

Commercial operations continue to refine their systems and procedures to improve efficiency. One threshold technology that will improve satellite operations is communications cross-linking from satellite to satellite. This technology has been proved on some DoD spacecraft, and it has the potential to eliminate the need for overseas ground stations during normal telemetry, tracking, and commanding. Cross-linking would result in tremendous savings for the government as well as simplify operations for future commercial low-Earth orbit satellites.

Applications

Space applications will be the backbone of the information age and show exponential growth in the coming decades. Revolutions in space-based information technology--weather, cellular telecommunications, paging, broadcast--affect not only government and industry but individuals' livelihoods internationally.

Space applications will enable countries to leapfrog from the industrial age directly into the information age. A lack of ground communications infrastructure will no longer hold a society hostage to the technological dark ages. This phenomenon is not evolutionary progress but rather a revolution that catapults the world into the information age.

GOVERNMENT GOALS AND ROLE

> *We're going to spend $125-150 billion--a lot of money--over the next 10 years on space programs, and currently I have nothing to take to the Defense Secretary that qualifies as a strategic plan . . . . There's no single master plan for spending $13 billion per year. That's personally unacceptable. It just doesn't pass the common sense test.*
>
> --Robert V. Davis, Deputy Under Secretary of Defense, Space

Define Policy

In 1995 a bipartisan, blue-ribbon panel convened by the congressional Office of Technology Assessment concluded that there is a "lack of consensus on U.S. space policy goals." With the dissolution of the National Space Council in 1993 and the subsequent move of space policy responsibilities into the Office of Science and Technology Policy (OSTP), this finding is hardly surprising.

To add to the confusion about space policy, during his Senate confirmation hearing on January 26, 1993, the president's science advisor, Dr. John H. Gibbons, testified that his priorities lay more with inner space than with outer space. This testimony, coupled with the fact that the highest White House official now responsible for overseeing space policy is only at the assistant director level in the OSTP, only validates the fact that the administration has placed a relatively low priority on space.

The executive branch must take vigorous steps to define a national space policy, vision, and strategic plan if the United States is to maintain its preeminence in the space arena. Other nations, such as Japan, France, and Germany, are building the technology to compete in along with the vision to penetrate the global market. The degree to which the United States can

maintain its leadership is directly proportional to the energy the nation devotes to developing and executing a national space strategy.

Key areas that the national space policy must address and in which the government must *take action* include the following.

Invest in Future Technologies

Reductions in capital investments and R&D funding (both government and private) will harm the satellite development sector more in the long term than will any current reductions in procurement. The government must work with industry to develop standardized payload configurations and satellite subsystems to reduce the payload-to-orbit cost, provide increased R&D funding for next-generation spacecraft to replace current systems, and provide incentives--through revised regulations and tax policy--for the industry to make significant R&D investments. The government, however, must fund the majority of fundamental science R&D. Finally, space policy must preclude the transfer of technology without a commensurate exchange, which would protect technology as an asset vice selling it as a commodity.

Teamwork with Industry

Foreign competition for launch services is and will be the greatest obstacle to growth in the U.S. space transportation market unless the government takes a more aggressive, protectionist stance --at least until U.S. commercial launch has an opportunity to benefit from lower-cost, modular EELV and its common launch infrastructure.

The government should also take further steps to provide low-cost or no-cost launch operations and range support for commercial launches. Currently, commercial launches are required to pay for the proportionate share of the range they use. If the government has the staff and facilities on hand, it should provide the services at no cost as a way to level the international playing field.

In another teamwork issue, the government should devise a strategy for taking advantage of the coming explosion of remote-sensing data from

commercial systems. The tremendous savings made possible by using commercial imagery for certain applications could be reinvested in future technologies. This strategy for using commercial products could also serve to bolster the industrial base by guaranteeing a certain level of orders for a company, thus improving its ability to secure financing.

Finally, the government should commercialize all routine satellite health and welfare operations. Firms have been supporting satellite operations for over 35 years, and significant savings across the board would result from simply hiring the "best in class"--a qualified contractor--to perform routine satellite operations.

Maintain the Industrial Base

Market forces will likely cause further downsizing and consolidation, but the government should implement a coherent policy for maintaining the U.S. space industrial base. This policy should include incentives for small businesses and lower-tier suppliers and provisions for the government to act as an "anchor-tenant" for a commercial firms attempting to develop and process new technologies.

Reform the Acquisition Process.

The government must also continue the progress made in reforming DoD acquisition to facilitate dual-use initiatives. Contractors cannot be required to maintain fully redundant production lines for commercial and government work just to meet procurement regulations. There must be concrete financial incentives for dual-use production. Because of market competition, multiyear procurement contracts can also yield significant benefits--in both planning and costs. Specific acquisition reforms for the space industry include:

- Embrace commercial standards in acquisition practices.
- Provide stability through multiyear procurement.
- Acquire commercial products instead of having the government build a unique end item..

- Support advanced technology demonstrations.

- Collapse the time it takes for an idea to evolve into a product.

- Support cooperative R&D agreements.

- Support the increased use of computer-assisted design and manufacturing and concurrent engineering.

CONCLUSIONS

The space industry plays a strategic role in the nation's future. The application of space technologies in future military operations will facilitate a U.S. global presence, knowledge on demand, space control, and power projection. All of these developments are made possible by designing spacecraft with modern, low-cost techniques, adapting innovative architectures that incorporate distributed satellite systems, developing affordable access to space, and embracing commercial standards in acquisition practices. Although on August 5, 1994, the White House announced a National Space Transportation Policy that attempted to improve the nation's launch situation, no strong national space strategy with a far-reaching vision has emerged. *The first and foremost need is to establish a strong national vision and a strategic plan that integrates all activities in space: military, civil, and commercial.*

To that end, the United States urgently needs an overarching national space policy to improve its competitiveness in the world market. Government and industry must work as a team to compete globally. We therefore strongly urge that the U.S. government:

- Establish a *quid-pro-quo* national policy that views technology as a national strategic asset and precludes its transfer without a commensurate exchange.

- Promote the modular design of satellites, interfaces ,and boosters.

- Offer free launch operations and range services to U.S. firms.

- Commercialize and privatize standard satellite control operations.

- Establish a government-industry team approach to the use of commercial space products and services.

- Fund R&D for fundamental science.

- Provide tax incentives for commercial R&D investment.

- Create a commercial environment that allows U.S. firms to control a share of the market for space products and services applications.

Space is a key part of the nation's economic and national security and the cornerstone of leadership in the information age. In the next century the space industry will require a clear, strong government policy and a willingness on the part of the government to work with industry to satisfy the right requirements--on time and at an affordable cost.

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TRANSPORTATION INDUSTRY STUDY REPORT 1996

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Lt Col Jack Hatfield, USAF
CDR Doreen Jagodnik, USN
Lt Col Ron Ladnier, USAF
CDR Dave Tennesen, Dept. of Commerce
LTC Charles A. Van Sistine, USA
Ms. B. J. White-Olson, Dept. of the Air Force
Mr. Charlie Williams, Dept. of the Air Force
Lt Col Terry Young, USAF

Faculty:
COL Anita Arms, USAF
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Mr. Wally Sansone, Dept. of the Navy

Places Visited (U.S.):
United Parcel Service, Burtonsville, MD
Port of Memphis, TN
USTRANSCOM, Scott Air Force Base, IL
Port of Baltimore, MD
Maersk Lines, Baltimore, MD
USNS CAPELLA, Baltimore, MD
SS JOHN BROWN
AMTRAK, Washington, DC
CONRAIL, Philadelphia, PA
International Intermodal Exposition, Atlanta, GA
CSX Intermodal, Atlanta, GA
Delta Airlines, Atlanta, GA
Federal Express, Memphis, TN
Port of Memphis, TN
Lash Intermodal Terminal Co., Memphis, TN
U.S. Army Corps of Engineering, Memphis, TN

Places Visited (International):
Rotterdam Rail Service Center, Netherlands
Van Der Vlist Special Transportation, Netherlands
MTMC-Europe, Rotterdam, Netherlands
Nedlloyd, Rotterdam, Netherlands
Nedlloyd EUROPA

Rotterdam Port Authority,
Netherlands
SeaLand Terminal,
Rotterdam, Netherlands
French National Railroad (SNCF), Paris
Charles de Gaulle Airport, Paris, France
Ministry of Defense, London, UK
Maersk Lines, London, UK
Baltic Exchange, London, UK
SEACO, London, UK
Ministry of Transportation, London, UK
British Airways, London, UK
Heathrow Airport Authority, UK

ABSTRACT

Today's transportation industry is well positioned for global expansion and competition. All segments of the industry are currently profitable and are actively seeking faster, better, and more efficient ways to do business, including more ways to make multimodalism into true intermodalism. However, some near-term capacity shortfalls and mobilization issues must be resolved to ensure that the industry can continue to fulfill national security requirements for transportation into the next century.

INTRODUCTION

Manufacturers, movers of raw materials and finished goods throughout the global marketplace, and the armed forces providing manpower, equipment, supplies, and support to humanitarian efforts or hostilities around the globe all need safe, reliable transportation to succeed.

For the purposes of this study, we reviewed the four major modes of transportation (air, sea, rail, and truck), each of which has its own industry structure, assets, and capabilities. We then looked at how well the modes work together to provide seamless transportation for both commercial and military movements. Finally, we compared current and potential industry capacity with the national security transportation requirements validated in the 1995 *Mobility Requirements Study Bottom-Up Review Update* (MRSBURU).

THE TRANSPORTATION INDUSTRY DEFINED

Global transportation is available from four distinct modes: air, sea, rail, and truck. In the past, each transportation mode operated independently of the others, in classic "stovepipe" fashion. Shipments that required the use of more than one mode were considered *multimodal*, but each leg of the trip was considered an individual shipment, with the shipper usually negotiating and coordinating. Competition within the transportation industry and today's dynamic, global business environment have led to the increased use of the new transportation strategy known as *intermodalism*, which seeks to minimize the seams in the transportation process in order to streamline movements, increase reliability, and reduce costs.

In most intermodal shipping, the shipper places the cargo into an owned or leased container at the point of origin, and the container is then transported via rail or truck to a seaport and loaded onto a container ship. After arrival at the destination port, the container is unloaded and tendered to rail or truck for delivery to the customer or consignee. This use of containers in intermodal logistics reduces staffing needs, minimizes in-transit damage and pilferage, shortens transit time because of reduced handling, and allows the shipper to take advantage of volume shipping rates. And, ideally, the movement is accomplished under a single bill of lading, with virtually no en-route interaction or effort required by the shipper.

Successful intermodalism is a function of four key dimensions. First, intermodalism requires connectivity between different modes of transportation. It is not enough for the different modes to be in proximity to each other; they must overlap. For example, a seaport provides intermodal capability when it has rail running along the dock so that cargo can be unloaded from a ship directly to a rail car. Second, cargo must be packaged in standard containers so that it can be handled more expeditiously. The internationally recognized 20-foot container is the most common example. Third, specially designed cargo-handling equipment is needed. Two examples are rail well cars that hold double- or triple-stacked containers and the huge cranes with spreaders that snatch containers weighing up to 80,000 pounds and load them on and off ships. Finally, a transportation system cannot be truly intermodal without information systems that track movement and manage the flow of cargo from origin to final destination.

CURRENT CONDITIONS

Air

The United States is truly an air-oriented nation. It contains more airports than are in the entire rest of the world, and they are serviced by more than 200 air carriers. Additionally, over 184,000 aircraft are registered in the United States, and 6 of the top 10 airlines in the world are U.S. carriers. Air transport is the "premium" way to move people and cargo in that it is both the fastest and most expensive mode. For most air carriers, passenger

revenues account for the vast majority of income, with cargo (at 4-6 percent of revenues) of little consequence. Air transport, often the most efficient means of transporting people, cannot compete with other modes in transporting low-value, high-bulk cargo. Most air freight, therefore, is high-value, time-sensitive material. Air carriers specializing in overnight, express, and small-package deliveries, such as Federal Express, United Parcel Service (UPS), and DHL, now account for more than 50 percent of domestic air freight.

After five years of staggering losses, the U.S. airline industry reported record profits of $5.3 billion in 1995, and airline stocks soared by over 46 percent. The latest Department of Transportation (DOT) statistics show that revenue passenger-miles exceeded 500 million, an increase of almost 90 percent in the past 15 years. Revenue ton-miles of freight exceeded 22 million, an increase of 125 percent since 1980. Even with these numbers, however, the airline industry's profits, at approximately 2 percent per year, trail nontransportation industrial profits by a full 3 percent. The main cost and profit driver is the cost of fuel, which often fluctuates significantly from one year to the next.

The DOT and the Air Transport Association project that the record-breaking profits posted by the U.S. airlines in 1995 will continue for the foreseeable future, with the majority of the industry's growth taking place internationally. Between 1987 and 1993, international traffic increased by 47 percent while pure domestic traffic increased by only 6 percent. This shift in market emphasis has generated an increasing number of alliances and mergers between domestic and foreign carriers. Yet the continued health of the air transportation industry remains closely tied to the overall U.S. economy, since 90 percent of airline profits are derived from passenger travel, and half of that figure is derived from business travel.

Sea

The U.S.-flagged deep-sea intermodal shipping industry carries merchandise between U.S. and foreign ports in direct connection with other merchant vessels in the world fleet. Strategic in nature, it is interconnected to the domestic segments of air, rail, and trucking at seaports. By nature, waterborne shipping is particularly suited for

movement of heavy, bulky, and low-value-per-unit commodities for which speed is not of primary importance.

The U.S. share of the global oceangoing shipping industry continues to be small. In 1993, only 17.0 million tons (16.2 percent) of a worldwide total of 104.8 million tons of commercial liner cargo was carried on U.S.-flagged vessels. In 1984 the U.S. total was 13.8 million tons, or 21.7 percent. The total value of liner cargo carried in 1993 was $344.7 billion, with U.S.-flagged vessels transporting $69.2 billion worth, or 20.1 percent of the total; in 1984 the U.S. share was $41.2 billion. The net earnings of the entire U.S.-flagged foreign-trade liner fleet were only $119 million in 1992.

In 1985, the U.S.-flagged fleet numbered 477 ships. By 1994, that number had dropped to 332 U.S.-flagged vessels actively engaged in commerce: 27 break-bulk cargo ships, 129 intermodal vessels, 154 tankers, and 20 bulk carriers. Since 1994, 30 U.S.-flagged vessels have either been scrapped as inefficient or reflagged to a flag-of-convenience. Although the United States has experienced a decline in the total number of ships in liner service, today's new ships are much larger, resulting in an 81 percent increase in actual liner tonnage carried by U.S.-flagged ships between 1984 and 1993.

Rail

Railroads have been moving the nation's freight and passengers for over 165 years. However, today's rail network is considerably more streamlined than its 19th century forebears. In 1994, 531 railroads in the United States operated over 169,000 miles of track. Motor vehicles and airplanes have made passenger trains nearly obsolete, and the remaining passenger rail service, Amtrak, is unprofitable. Instead, modern U.S. railroading is focused on long-haul, heavy cargo movements--for which it is well suited, including commodity moves, such as coal and grain, and the transport of intermodal containers, motor vehicles, and heavy equipment.

In the 1960s and 1970s, transportation pundits predicted that the U.S. railroad industry was in its death throes. Saddled with an obsolete infrastructure, a bloated and strongly unionized labor force, and pervasive federal regulation, railroads were unable to compete with the trucking

industry for the nation's freight business. Yet today's railroads are strong once again. In 1994, they carried 1.2 million revenue ton-miles, nearly 40 percent of the nation's freight, for an annual revenue of over $33 billion and a 30 percent increase over 1980 levels. This profitability was reflected in Standard & Poor's rail stock index, which grew 198 percent between 1987 and 1994.

The railroad industry's turnaround was made possible in large measure by the consolidation of railroad companies through acquisitions and mergers. Today only 10 Class I railroads (those with revenues over $255.8 million) remain in the United States, down from 40 in 1979. This dramatic concentration is also seen in the industry's market-share breakout: in 1974, the 5 largest U.S. railroads earned only 40 percent of total railroad revenue, while in 1994 the top 5 railroads accounted for 85 percent of industry revenue. The consolidated railroads have been able to eliminate duplicative overhead, shed unproductive lines, update infrastructure and equipment, and make better use of labor resources. In addition, deregulation has allowed them to get out of unprofitable business sectors and focus on what railroads do best: move freight over long distances. Thus the average length of a railroad haul rose from 515.1 miles in 1970, to 615.8 miles in 1980, to 816.8 miles in 1994.

The deregulation and consolidation of the industry have facilitated several other rail transport initiatives. Railroads now conduct business under shipping contracts that set negotiated rates by shipper and commodity. Shippers benefit from reduced shipping rates and guaranteed service, while railroads benefit from more level, predictable business activity and improved equipment utilization. An estimated 60 percent of rail freight now moves under nearly 40,000 contract agreements. Additionally, the pooling of limited capital investment funds has allowed railroads to make substantive improvements to their industry-funded infrastructure, including centralized traffic control systems, more powerful and fuel-efficient locomotives, electronically controlled brakes, sophisticated signaling systems, and modern, intermodally configured rolling stock. Finally, merged networks of modern trackage and equipment have facilitated the interaction with other transportation modes necessary for intermodalism and in-transit visibility.

Trucks

The trucking industry moves products from one point to another using either for-hire carriers, which transport freight that belongs to others, or private carriers, which are operated by individual manufacturers, wholesalers, and merchants for delivery of their own goods. General freight carriers generate the majority of all truck revenues. Specialized carriers include carriers of heavy machinery, liquid petroleum, refrigerated products, agricultural commodities, motor vehicles, building materials, and household goods.

As a strategic industry, trucking offers flexibility and versatility. An efficient motor carrier can compete with an air carrier on point-to-point service for a shipment of any size for distances of fewer than 500 miles. Trucks can compete with rail carriers for truckload-sized shipments that are transported 500 or more miles and weigh less than 100,000 pounds. And since the present intermodal infrastructure is not fully capable of seamless rail-sea, rail-air, or air-sea connectivity, trucks usually fill the seams and function as the linchpins of the intermodal process. In 1995, 77 percent of total freight revenue and 45 percent of total freight tonnage moved by truck, and trucking accounted for 3 percent of the nation's gross domestic product (GDP). In terms of productivity, freight movement by trucks has increased by 60 percent since the 1980s, to over 880,000 million ton-miles in 1993. The total revenue of the trucking industry increased by 87 percent over the same period to over $292 billion in 1992.

Over 5 million Americans are employed in truck-related occupations. The number of trucks on U.S. roads has grown by 35 percent since 1980, reaching over 45 million registered trucks in 1992, and the number of new trucks added to the fleet every year has remained steady at 8-10 percent, indicating a healthy replacement rate as trucks stay in service for about 10-12 years. This fleet of trucks travels a network of paved roads that measured over 2.4 million miles in 1992, an increase of 15 percent since the 1980s. And the highway infrastructure receives over $150 million annually from federal, state, and local governments. While environmental issues remain a major concern, trucks have reduced carbon monoxide emissions by 37 percent and fuel consumption by 17 percent since 1980. Positive safety trends have also produced a 16 percent reduction in truck accidents over the past 30 years.

OUTLOOK

In general, we found the transportation industry to be well positioned to pursue further expansion and global competition. All segments of the industry are currently profitable and are actively seeking faster, better, and more efficient ways to do business, including more ways to make multimodalism into true intermodalism.

The Federal Aviation Administration (FAA) forecasts that air traffic growth will continue at 4 percent per year domestically and 5.8 percent internationally through 2006. Domestic air freight growth is expected to continue at 6-7 percent per year through 2013, while international air-freight traffic is projected to grow at almost 18 percent per year. Anticipated growth in the international container shipping market has led to the purchase of 100 new, large-capacity container ships, to be delivered by 1997, representing a 27 percent increase in the world containership fleet. More than 40 of these ships are expected to be used in the U.S. trade lanes, which should accommodate the projected 1996 U.S. trade growth of 6 percent for imports and 10 percent for exports. Similarly, railroad analysts predict another 2.4 percent increase in rail traffic, following 10 consecutive years of similar traffic gains. Intermodal business, which is expected to make up the bulk of the rail increase, is predicted to grow about 4.8 percent annually through 2004, to 13 million units. Additionally, regional and short-line railroad companies will continue to grow, creating new markets on feeder lines abandoned by the major railroads. The American Trucking Association predicts that the trucking industry should see healthy revenue increases estimated at 24 percent over the next decade. And ports will continue to play an essential role in the U.S. economy, with foreign trade through the port system expected to surpass 20 percent of GDP by 1998.

CHALLENGES

We found that the industry is, for the most part, currently capable of supporting mobilization requirements consistent with two nearly simultaneous major regional conflicts (MRCs). However, some near-term capacity shortfalls and mobilization issues must be resolved to sustain this

capability into the next century. Following are some specific challenges for the transportation industry.

Surface Transportation

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 increased government funding levels for surface transportation programs and gave them more flexibility. The ISTEA established authorizations for highways, highway safety, and mass transportation that amount to about $155 billion more than in FY 1992-97. The purpose of the act is clearly enunciated in its statement of policy: "To develop a National Intermodal Transportation System that is economically efficient, environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner." Follow-on legislation currently being discussed in Congress would extend this funding commitment past 1997.

Air

Increased competition, brought about by deregulation since 1978, has forced some less competitive and less viable air carriers to close their doors and others to merge in order to stay viable. Stiff competition will continue to force closures and mergers in the future. The main challenges facing the domestic airline industry include international access and competition, government policies and requirements, and infrastructure and prime equipment requirements for the next century. Airlines are faced with huge capital investment requirements if they are to maintain state-of-the-art aircraft in their fleets. Older aircraft are less fuel efficient and grow increasingly expensive to operate and maintain. New, replacement aircraft have smaller crew requirements and more quiet, fuel efficient engines, but purchase prices can easily exceed $100 million. And those carriers fortunate enough to be able to procure new aircraft are faced with a shrinking number of commercial aircraft suppliers.

A relatively new feature in the industry is globalization of airlines. A 1995 General Accounting Office report stated that existing bilateral pacts between the United States and 72 other nations greatly restricted the airlines' ability to participate in foreign markets (General Accounting Office, 1995). The result is that more and more carriers have entered into

code-sharing agreements whereby U.S. and foreign carriers agree to share flight numbers, passengers, and even equipment to ensure access to international markets. Since 1992, the number of code-sharing agreements has increased from 19 to 61. Three of these alliances--Northwest/KLM, USAir/British Airways, and United/Lufthansa--are considered "strategic" since they affect key routes and assets. Industry analysts fear that the continued growth of code-sharing agreements could result in decreased competition as large, multicarrier alliances deny market access to non-alliance members. Code sharing could also have a negative affect on U.S. national security. If domestic carriers become too reliant upon code sharing for access into international markets, they will be less inclined to purchase and maintain large, wide-body aircraft for international overseas flights. Without these aircraft in their inventories, domestic carriers will be unable to adequately support Department of Defense (DoD) mobilization requirements.

This situation could become further complicated by carrier mergers, especially mergers of domestic and foreign carriers, which may result in the complete loss of control over what had been purely domestic carriers. For example, British Airways now owns just under 25 percent of USAir and has three seats on USAir's 16-member board of directors. U.S. law currently restricts foreign interest in U.S. airlines to less than 25 percent. A 1991 interpretation of the law by then-Secretary of Transportation Samuel Skinner allowed foreign investment of up to 49.9 percent in "total equity" and voting interest of less than 25 percent. In 1993, the U.S. Commission on Airline Competitiveness recommended that foreign investors be permitted to control 49 percent of voting interest in the belief that the less-than-majority control would still ensure strategic access to Civil Reserve Air Fleet (CRAF) aircraft and crews. The CRAF program, the cornerstone of the U.S. strategic civilian airlift capability, is a civil/military partnership, administered by the DOT, under which commercial air carriers contractually agree to provide aircraft and crews to support DoD airlift requirements in national defense emergencies. If foreign carriers gain veto authority over U.S. commercial aircraft use in wartime, the national security of the United States will be compromised.

Strategic Airlift

The MRSBURU validated an airlift requirement of 53 million ton-miles per day (MTM/D) as the baseline for U.S. strategic airlift capability. The introduction of the C-17 into the Air Force inventory, combined with a viable CRAF program, ensures that the DoD can meet its stated strategic airlift requirement. As the DoD continues to shrink, however, the amount of DoD business offered to CRAF members as the main incentive for their continued participation in the program will also decrease. The DoD must, at the very least, be aware of the decreasing incentive for CRAF participation and find additional incentives for the carriers.

CRAF currently provides over 18 MTM/D of the DoD-approved 53 MTM/D airlift requirement, equaling over 90 percent of the U.S. long-haul passenger capability, more than 30 percent of the U.S. long-haul cargo capability, and 36 percent of the U.S. aeromedical evacuation capabilities. However, no U.S. carriers have purchased CRAF-compatible wide-body aircraft since 1988, and the average age of the CRAF fleet is 22.7 years (63 percent of the fleet is over 25 years old). CRAF compatibility implies that the aircraft will readily accept the standard DoD cargo pallets, has been modified for rapid conversion to a cargo configuration, or has been modified for conversion to a medical evacuation configuration. The government encourages carriers to purchase CRAF-compatible aircraft, such as the Boeing 747-400, but they cost considerably more than the aircraft preferred by most carriers. Today's best-selling commercial aircraft are more fuel efficient, use two engines as opposed to the 747's four, and require fewer crew members to operate. They can also cost up to 50 percent less than the 747 ($150 million per 747 versus $80 million for the MD-11 or Boeing 767, or $45 million for the European-built A300). The DoD should consider subsidizing the purchase of CRAF-compatible aircraft to ensure that carriers keep a minimum number in their fleets for mobilization needs.

Another CRAF incentive is the Commercial Access to Military Installations program, which provides carriers access to new airfields and geographical areas of operation. In addition, carriers could save millions of dollars in fuel expenses by using military installations as transfer points or alternative emergency landing sites. The Federal Acquisition Streamlining Act allows the DoD to open its military fields to commercial

CRAF members, but DoD components (i.e., base commanders) have been slow to accept the practice.

The government and carriers negotiated new CRAF rates. During Operations Desert Shield and Desert Storm, however, carriers received less than 50 percent of what they believed was a fair and reasonable rate for the services they provided. In addition, the carriers' request for additional War Risk Insurance proved to be a major point of contention. The DoD cannot expect full support for CRAF unless it is willing to minimize the tension between itself and the carriers in light of the decreasing amount of business it can offer in peacetime and its increasing dependence (now over 50 percent of DOD's potential airlift capability) upon the CRAF program in wartime.

Airports

While the nation's aging air traffic control (ATC) system has not contributed to any accidents, it has had several breakdowns that resulted in significant disruption and delays in commercial air traffic. The FAA began to upgrade the current system in 1981, but despite 15 years and several billion dollars, it has not succeeded, as its efforts have fallen victim to the lengthy federal acquisition planning process and the "requirements creep" inherent in the desire to take advantage of continuing technological innovations. Efforts to incorporate the latest technologies into planning and funding cycles have driven up costs and resulted in significant system delays. Contributing to this situation was the FAA's lack of experience in major systems definition, acquisition program management, and contractor oversight requirements. These factors, coupled with the fact that the FAA has had seven administrators in the past 10 years, were a recipe for acquisition failure. During these years of futility, projected acquisition costs for ATC replacement systems have risen by more than 50 percent. While the latest projections are that a new ATC will be fielded at the turn of the century, the government should pay concentrated attention to the management and funding of this critical program. The health, safety, and stability of the U.S. air transportation industry is closely tied to the ability to control air traffic.

Sea

The maritime shipping industry is the last bastion of heavy federal regulation of transportation. The maritime deregulation legislation currently before Congress contains several elements that may result in more competition for available freight and a consolidation of major carriers. The most important are contract confidentiality, elimination of tariff filing, and the sunset of the Federal Maritime Commission. As in the now-deregulated air industry, this increased competition will encourage the emergence of new global transportation alliances that will allow ocean carriers to share not only assets, such as vessels, but also container equipment and terminal facilities.

The greatest challenge facing today's U.S. merchant marine fleet is the ongoing debate over the role of subsidies in maintaining an adequate U.S. capability to meet national defense needs. U.S. mobility plans rely heavily on the U.S.-owned merchant fleet for the sustainment of U.S. forces deployed overseas, and subsidies have been considered a cost-effective means of ensuring that military-useful vessels, primarily container and a small number of roll-on/roll-off (RO/RO) ships, are available. The Operating Differential Subsidy (ODS), which expires in 1997, offsets higher costs associated with all-U.S.-citizen mariner crews. The new subsidy program, the Maritime Security Act of 1995, would provide approximately $2 million per ship for 50 U.S.-flagged ships, but is currently stalled in the Senate. Proponents argue that the subsidy is necessary to guarantee that U.S.-flagged and -operated shipping is available to ensure support in a contingency. Opponents believe that the 10-year program's $1 billion price tag is too steep and that U.S. cabotage laws (the Jones Act) and government cargo preferences adequately support sufficient sustainment capacity in the U.S.-flagged fleet. Subsidy opponents also note that U.S. shipping that does reflag will remain under effective U.S. control and will continue to be available to meet defense needs. Subsidy programs must be balanced against the need for other maritime programs, such as the procurement of additional surge RO/ROs, large, medium-speed RO/ROs (LMSRs) and afloat pre-positioning vessels for the U.S. Ready Reserve Force (RRF). The RRF was created to maintain a surge shipping and resupply capability that would be available on short notice to support the development of a multidivision force.

Strategic Sealift

The United States, as evidenced during Operations Desert Shield and Desert Storm, maintains an immense capacity for projecting military power abroad. Key to this ability are U.S. sealift assets, both organic military and commercial. Broadly defined, U.S. sealift is divided into three categories: afloat pre-positioning, surge, and sustainment. The categories of most concern are pre-positioning and surge sealift, the organic lift required to rapidly move the material that comprises elements of Army divisions and Marine Corps forces in the initial stages of an operation. Current RRF capability is approximately 3.8 million square feet short of the 10 million square feet of surge lift required in 2001. The organic pre-positioning and surge shipping shortfalls will be made up by the acquisition of 19 LMSRs. The lead LMSR was completed in May 1996, and the program is currently funded through the 13th vessel, but construction delays have stretched final delivery 15-22 months beyond the original goal. Furthermore, another key component of the surge program is the acquisition of five additional RO/ROs. The outcome of this purchase is also in question because of congressional reluctance to buy foreign-built ships, even though money is not currently available to purchase more expensive, U.S.-built RO/ROs.

In the area of sustainment shipping, the number of liner vessels worldwide will continue to increase, but the number of U.S.-flagged vessels will continue to shrink, taking with it a significant number of U.S. civilian mariner positions. This trend may create shortages of RRF crews in the future.

Seaports

Today over 175 commercial cargo ports in the United States each handle in excess of 250,000 tons of cargo annually. In 1992, U.S. seaports handled approximately 2.9 billion metric tons of cargo and supported over 15 million jobs, with approximately 95 percent of all U.S. exports and imports passing through U.S. seaports annually. Seaports also play an important role in national security by handling essential cargoes for military operations. Over the past two decades, however, a number of factors have complicated the development, operation, and maintenance of the nation's harbors, particularly in the area of dredged material

management. These factors include increases in the demands of commerce, the rapid evolution of shipping practices (containerization and intermodalism), heavy population shifts to coastal areas, increasing environmental awareness, and a general lack of fiscal support for port development projects. Of primary concern to the deep-draft port facility owners is the need to develop dredging operations for essential harbor and berthing areas in a timely and cost effective manner, consistent with environmental quality controls. One of the principal difficulties in the dredging process is how to manage and dispose of dredged material, some of which has been contaminated by years of harbor pollution. A major challenge is to evaluate the presence of contaminants in the dredged material and then identify the best scientific method of segregating contaminated sediments from the marine environment.

Several legislative concerns serve as challenges to the survival of the ports system. For example, the Tax Reform Act of 1986 has inhibited the ability of public ports to issue tax-exempt bonds to finance needed infrastructure and functionally related facilities. The Water Resources Development Act of 1990 is inadequate to support the dredging requirements of most U.S. ports. Finally, changes to the ISTEA will have a direct bearing on the port structure, an increasingly critical component to an integrated intermodal transportation system.

Rail

Perhaps the greatest single concern about railroad mergers is reduction in competition and its associated pressure on shipping rates. For example, the recent spate of mega-mergers, if allowed to continue, will create two railroad giants in the West: Union Pacific and Burlington Northern Santa Fe will control 90 percent of car holdings west of the Mississippi and 60 percent of total industry revenues. Such consolidation has led to concern over monopolistic pricing and routing decisions. Railroad mergers and the streamlined intermodal long-haul network have also affected overall railroad capacity. The Staggers Rail Act of 1980 made it easier for railroads to abandon unproductive rail lines, and the industry rapidly took advantage of this opportunity. Railroad trackage has now been reduced from 217,552 miles in 1960 to less than 120,000 miles today, a significant reduction in rail access, with most service interruptions on branch and feeder lines.

Trucks

The trucking industry faces the challenge of an aging and static infrastructure that will be inadequate to meet the increasing demands of the future. In the past 30 years, the highway infrastructure, consisting of roads, bridges, and tunnels, has come to play a vital role in supporting the nation's growing economy. The future portends steady growth in the U.S. population and globalization of commercial trade that will require a larger and more efficient highway network. However, current highway facilities are characterized by deferred maintenance, saturated capacity, and lack of expansion projects. The U.S. highway infrastructure is aging, deteriorating, and breaking down, as evidenced by deficient bridges and roads and congestion on urban interstate highways. An inadequate and inefficient highway network constrains productivity, increases operating costs, endangers public safety, and inhibits U.S. competitiveness in the global economy. The United States must commit to a national agenda of preserving existing facilities that are in sound condition and enhancing the capacity of the infrastructure to meet the transportation needs of the future.

Another challenge for trucking is an inadequate manpower base in the accession and retention of high-quality drivers. And the continued demand for a cleaner and safer environment may lead to new restrictions on truck operations or fuel use, more expensive vehicle and driver operating standards, or new taxes on diesel fuel. Such measures would affect the operating costs of the trucking industry and, ultimately, the cost to the consumers.

In-Transit Visibility

The DoD is faced with the challenge of developing and implementing an automated In-Transit Visibility (ITV) system that is synchronized with ITV systems in the commercial marketplace. ITV is the automated capability to identify and track the movement of defense cargo, passengers, medical patients, and personal property from origin to final destination during peace and war within either the commercial or defense transportation pipelines. The change in U.S. military strategy from "forward presence" to "CONUS-based power projection force" relies on

ITV to plan, execute, and sustain the rapid deployment of combat and support units.

While the DoD is implementing the Global Transportation Network (GTN), which is designed to be compatible with asset-visibility systems in the commercial sector, some concerns remain. In the commercial sector, the various modes of transportation differ in their ability to provide ITV data at the GTN level of detail. The air and truck transportation leaders, such as Federal Express and UPS, have invested heavily to obtain real-time and detailed data on movement of material. By establishing the processes, systems, and manpower required to track material movement on a detailed level, these companies increased their competitive advantage in their business. However, rail and sea transporters move primarily containerized cargo that is not time sensitive. Thus to compete they do not have to provide detailed, real-time ITV information. This lack of standardization in commercial systems affects impacts the DoD′ s overall effort to achieve in-transit visibility for all DoD material.

GOVERNMENT GOALS AND ROLE

We recommend the following roles for the government in ensuring the future health of the U.S. transportation industry in an increasingly global competitive environment and in ensuring that the United States has adequate shipping capacity to meet national security requirements.

1. Despite 1991's ISTEA initiative, there remains a lack of national leadership in establishing a comprehensive strategy for intermodal transportation. The federal government must take the lead in breaking down the transportation modal stovepipes, beginning with reorganizing the DOT, restructuring infrastructure funding streams, and collecting data on intermodal activities.

2. The government's role in regulating the economic aspects of U.S. transportation has diminished considerably over the past 20 years, yielding substantial savings for consumers of transport and a major increase in flexibility and shipping options. This trend should continue; residual federal regulation should be confined primarily to the areas of

safety, environmental issues, interoperability, and adequate market competition within each mode.

3. The United States should eliminate direct maritime subsidies. The U.S. maritime industry and many defense officials contend that these subsidies are necessary to offset the higher costs of U.S. mariners required on U.S.-flagged ships, but we believe current cabotage laws and government cargo preference policies are adequate to maintain a responsive U.S.-flagged fleet. In addition, those U.S. ships that reflag will remain under effective U.S. control and will still be available to meet national security needs.

4. To meet surge requirements, the government must fund the purchase of five additional RO/ROs, keep the LMSR program funded, and avoid further slippages in their delivery.

5. The United States must implement policies to ensure that an adequate number of U.S. mariners are available to man the RRF. The government should consider giving mariners an annual stipend, similar to the bounty program used by the British, in exchange for RRF availability. Additionally, Congress should pass legislation guaranteeing reemployment rights for mariners called away from civilian jobs. We also recommend establishing agreements with labor unions in order to (1)use available manpower more effectively by reducing RRF crews to a size that is in line with current international merchant marine practices and (2) identify and train unlicensed deck personnel on inland waterways for assignment to RRF ships.

6. The DOT must ensure the viability of the nation's ATC system. Confusion and setbacks in the ATC upgrade program have shaken the confidence of both the industry and its customers. With air traffic predicted to increase, the DOT leadership must put the full weight of its attention on resolving this potential crisis.

7. The DoD must continue to give commercial air carriers incentives to participate in the CRAF program and must give full consideration to subsidizing the purchase of CRAF-compatible aircraft.

8. The DoD must ensure that it remains compatible with the rapidly evolving commercial sector in such trends as containerization of cargo, intermodal handling procedures and equipment, and information systems.

9. The federal government must initiate partnerships with state and local governments and private industry to plan, finance, and construct new facilities and additional capacities in the transportation network. One source of financing is through direct user fees such as take-off and landing charges for air carriers and road/bridge tolls for surface carriers. Federal funds must be allocated to projects that improve the performance of the national system as an integrated transportation network.

CONCLUSIONS

The U.S. transportation industry is healthy and growing stronger. As intermodalism becomes inculcated into business practices, all segments of the industry will synergistically interact to provide seamless service at an efficient and cost-effective rate. Working together, the country's organic military and commercial transportation assets provide most of the lift required to support the two-MRC scenario. The shortfalls that do exist have been specifically addressed by the current administration and will, for the most part, be rectified by acquisition of the C-17 aircraft and additional LMSR vessels. Finally, the government has a definite role to play in repairing or replacing the nation's aging transportation infrastructure. While there is some room for improvement, our study concluded that the United States is the world leader in transportation and will remain so as the nation moves into the next century.

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*U.S. G.P.O.:1996-405-201:40015